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Environmental Protection
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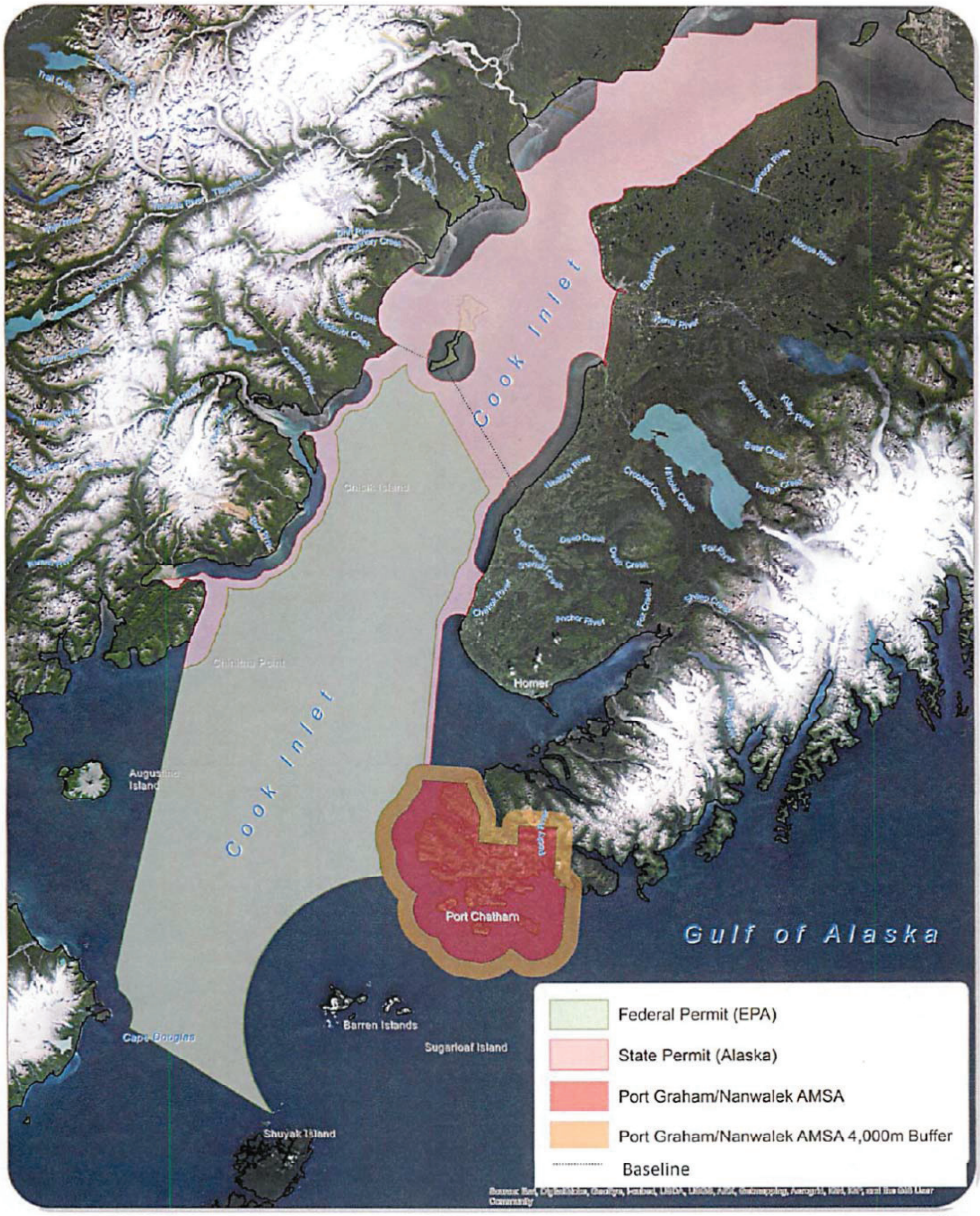
PRELIMINARY DRAFT
OCEAN DISCHARGE CRITERIA EVALUATION FOR THE COOK INLET EXPLORATION GENERAL PERMITS



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1.0 INTRODUCTION

1.1 PURPOSE OF EVALUATION

The U.S. Environmental Protection Agency (EPA) and the Alaska Department of Environmental Conservation (DEC) intend to issue National Pollutant Discharge Elimination System (NPDES) and Alaska Pollutant Discharge Elimination System (APDES) General Permits, respectively, under Clean Water Act (CWA) § 402 for discharges from Oil and Gas Exploration facilities operating in federal and state waters of Cook Inlet, Alaska. CWA § 403(c) requires that CWA § 402 (NPDES and APDES) permits comply with EPA's Ocean Discharge Criteria for preventing unreasonable degradation of the marine environment of the territorial seas, the contiguous zones, and the oceans. The purpose of this Ocean Discharge Criteria Evaluation (ODCE) is to discuss and evaluate the discharges from oil and gas exploration facilities.

This ODCE evaluates both EPA's and DEC's general permits and their potential to cause unreasonable degradation of the marine environment within the territorial seas, contiguous zones and the oceans within the coverage areas. For simplicity, the draft permits are referred to together as the 'proposed Cook Inlet Exploration general permits' in this document.

This document evaluates the impacts of waste water discharges associated with the proposed Cook Inlet Exploration general permits from exploration activities. Development and production activities, and their associated discharges, are not covered by the general permits. As such, development and production operations are outside the scope of the activities considered in this ODCE and are not discussed in this document.

EPA's Ocean Discharge Criteria (40 Code of Federal Regulations (CFR) Part 125, Subpart M) set forth specific determinations of unreasonable degradation that must be made prior to permit issuance. "Unreasonable degradation of the marine environment" is defined (40 CFR 125.12[e]) as follows:

1. Significant adverse changes in ecosystem diversity, productivity, and stability of the biological community within the area of discharge and surrounding biological communities;
2. Threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms; or
3. Loss of aesthetic, recreational, scientific, or economic values, which are unreasonable in relation to the benefit derived from the discharge.

This determination is to be made on the basis of considering the following 10 criteria (40 CFR 125.122):

1. The quantities, composition, and potential for bioaccumulation or persistence of the pollutants to be discharged;
2. The potential transport of such pollutants by biological, physical or chemical processes;
3. The composition and vulnerability of the biological communities that may be exposed to such pollutants, including the presence of unique species or communities of species, the presence

of species identified as endangered or threatened pursuant to the Endangered Species Act (ESA), or the presence of those species critical to the structure or function of the ecosystem, such as those important for the food chain;

4. The importance of the receiving water area to the surrounding biological community, including the presence of spawning sites, nursery/forage areas, migratory pathways, or areas necessary for other functions or critical stages in the life cycle of an organism;
5. The existence of special aquatic sites including, but not limited to, marine sanctuaries and refuges, parks, national and historic monuments, national seashores, wilderness areas, and coral reefs;
6. The potential impacts on human health through direct and indirect pathways;
7. Existing or potential recreational and commercial fishing, including finfishing and shellfishing;
8. Any applicable requirements of an approved Coastal Zone Management Plan;
9. Such other factors relating to the effects of the discharge as may be appropriate; and
10. Marine water quality criteria developed pursuant to Section 304(a)(1)

If the Regional Administrator determines that the discharges will not cause unreasonable degradation to the marine environment, an NPDES permit may be issued. If the Regional Administrator determines that the discharge will cause unreasonable degradation of the marine environment, an NPDES permit may not be issued.

If the Regional Administrator has insufficient information to determine, prior to permit issuance, that there will be no unreasonable degradation to the marine environment, an NPDES permit will not be issued unless the Regional Administrator, on the basis of the best available information, determines that all of the following are true:

1. such discharge will not cause irreparable harm[1] to the marine environment during the period in which monitoring will take place;
2. there are no reasonable alternatives to the onsite disposal of these materials; and
3. the discharge will be in compliance with certain specified permit conditions (40 CFR 125.122).

1.2 SCOPE OF EVALUATION

This document evaluates the impacts of discharges as provided by the ‘proposed Cook Inlet Exploration general permits’ for oil and gas exploration facilities in federal and state waters in Cook Inlet.

This document relies extensively on information provided in the Cook Inlet Planning Area Oil and Gas Lease Sales 191 and 199 Final Environmental Impact Statement (MMS 2003); the general permit fact

[1] *Irreparable harm* is defined as “significant undesirable effects occurring after the date of permit issuance, which will not be reversed after cessation or modification of the discharge” (40 CFR 125.121[a]).

sheet; ODCE, Environmental Assessment and Biological Evaluation for the 2007 Cook Inlet NPDES Permit (Tetra Tech 2006); the Ocean Discharge Criteria Evaluation for the Forest Oil Osprey Platform, Redoubt Shoal Unit Development Project (SAIC 2001); and the Environmental Assessment for the New Source NPDES Forest Oil Redoubt Shoal Unit Production Oil and Gas Development Project (SAIC 2002).

For more detailed information concerning certain topics, where appropriate, this document will refer to these publications. The information presented in this ODCE is a synthesis of the information in these documents in addition to findings published in scientific literature.

1.2.1 Area of Coverage of the Draft NPDES General Permits and Applicability of this ODCE

This document evaluates the impacts of wastewater discharges proposed to be authorized by the proposed Cook Inlet NPDES general permits for oil and gas exploration facilities pursuant to CWA § 403(c) which applies to discharges into the territorial sea, waters of the contiguous zone, or the oceans. As illustrated in Figure 1, the territorial seas and federal waters subject to this ODCE are the waters south of the baseline near Kalgin Island. Waters north of Kalgin Island and landward of any baseline within the bays in southern Cook Inlet are coastal waters not subject to the ODCE regulations and are not analyzed in this document.

The proposed Cook Inlet Exploration general permits will cover exploration facilities in federal and adjacent state waters of Cook Inlet except the prohibited areas described in section 1.2.2.

1.2.2 Prohibited Areas of the Proposed Cook Inlet Exploration General Permits

EPA proposes to continue the discharge prohibitions in the 2007 NPDES general permit in the following areas:

- In water depths less than the 10 meter mean lower low water (MLLW) isobath;
- Shoreward of the 5.5 meter isobath adjacent to either (1) the Clam Gulch Critical Habitat Area or (2) from the Crescent River northward to a point one-half mile north of Redoubt Point;
- In Kamishak Bay, west of a line from Cape Douglas to Chinitna Point;
- In Chinitna Bay, inside of the line between the points of the shoreline at latitude 59°52’45’’ N, longitude 152°48’18” W on the north and latitude 59°46’12” N, longitude 153°00’24” W on the south;
- In Tuxedni Bay, inside of the lines on either side of Chisik Island
    - From latitude 60°04’06” N, longitude 152°34’12” W on the mainland to the southern tip of Chisik Island (latitude 60°05’45” N, longitude 152°33’30” W)
    - From the point on the mainland at latitude 60°13’45” N, longitude 152°32’42” W to the point on the north side of Snug Harbor on Chisik Island (latitude 60°06’36” N, longitude 152°32’54” W)

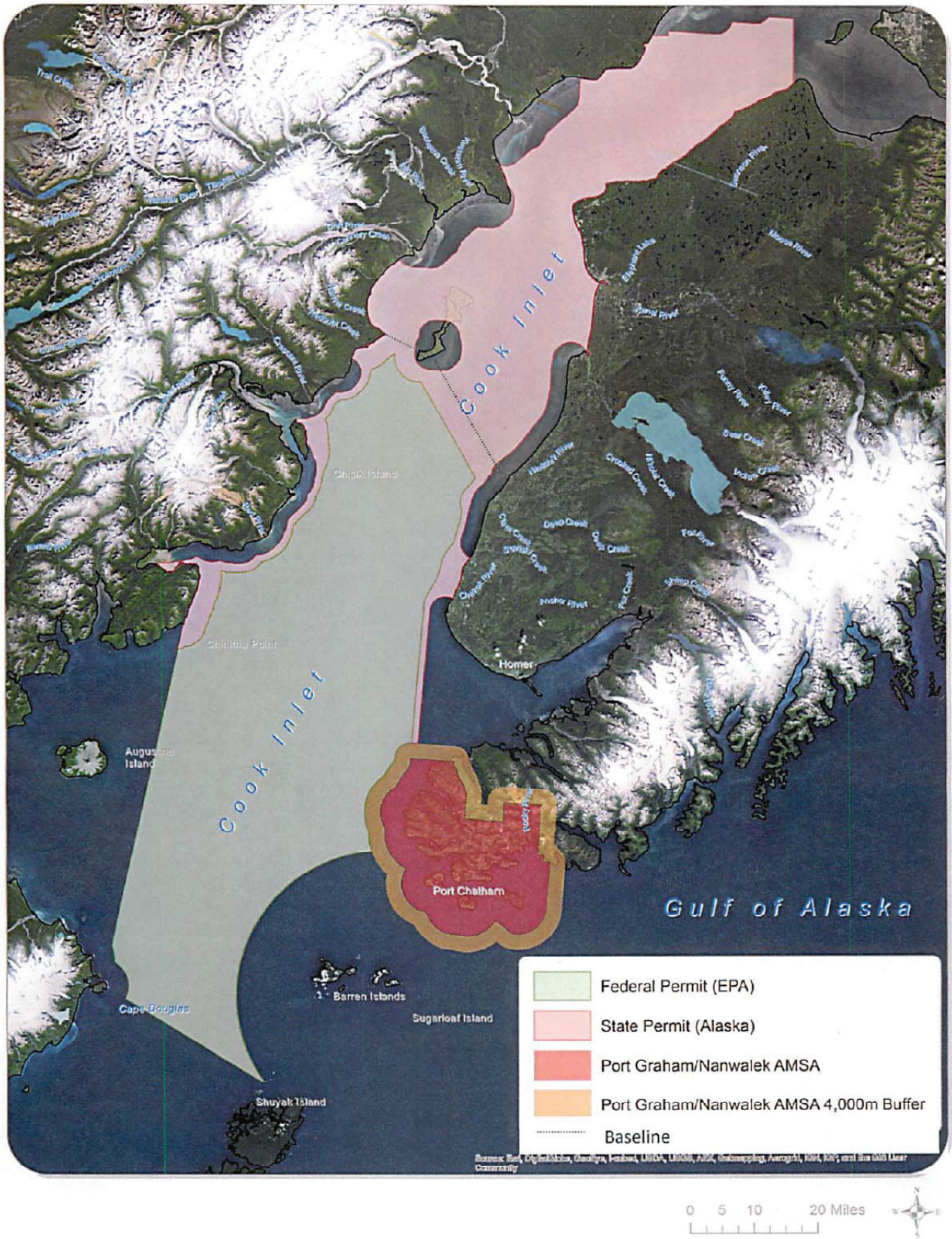

Figure 1: Area of Coverage for Proposed General Permits

The 2007 NPDES general permit prohibits discharges in waters with a depth less than 10 meters for exploration facilities because discharges to shallow waters are less likely to be dispersed than discharges to deeper water. This prohibition reduces the potential to impact the abundant aquatic life generally found in shallow waters.

The 2007 NPDES general permit prohibits discharges in parts of Chinitna, Tuxedni, and Kamishak Bays because they are either areas of high resource value, or are adjacent to areas of high resource value. In addition, Kamishak Bay is a known net depositional environment where drilling fluid solids, cuttings, and other pollutants would likely accumulate if discharges are authorized in that area.

In addition to the discharge prohibitions described above, the proposed Cook Inlet Exploration general permits would prohibit discharges in the following areas:

- In Shelikof Strait south of a line between Cape Douglas (at 58°51' N, 153°15' W) on the west and the northernmost tip of Shuyak Island on the east (at 58°37' N, 152°22' W);
- Within 20 nautical miles of Sugarloaf Island as measured from a centerpoint at 58°33' N and 152°02' W; and
- Within the boundaries, or within 4,000 meters of a coastal marsh, river delta, or river mouth, or a State Game Refuge (SGR), State Game Sanctuary (SGS), Critical Habitat Area (CHA), Area Meriting Special Attention (AMSA) or National Parks. (The seaward edge of a coastal marsh is defined as the seaward edge of emergent wetland vegetation).

The Shelikof Strait area described above was outside of the 2007 NPDES general permit coverage area. However, because the National Marine Fisheries Service (NMFS) has designated Shelikof Strait as a special aquatic foraging area for the Stellar Sea Lion (see 58 Federal Register (FR) 45278 (September 27, 1993); and also 50 CFR 226.12(c)(1)), the general permit prohibited discharges in Shelikof Strait.

The 2007 NPDES general permit prohibited discharges within 4,000 meters of a coastal marsh, river delta, or river mouth, or a SGR, SGS, AMSA, or CHA to afford better protection of these sensitive areas. In the proposed Cook Inlet Exploration general permits, EPA and DEC propose to retain this prohibition. EPA is not aware of any plans for oil and gas activities in those areas. Furthermore, with modern drilling technologies, such as directional or extended reach drilling techniques, discharges within this buffer zone can be avoided. The following SGRs, SGSs, CHAs, AMSA and National Park are in the proposed Cook Inlet NPDES general permit coverage areas:

Clam Gulch CHA	Trading Bay SGR
Kachemak Bay CHA	Redoubt Bay CHA
Lake Clark National Park	Susitna Flats SGR
Kalgin Island CHA	Port Graham AMSA

2.0 DESCRIPTION OF EXPLORATION ACTIVITIES

2.1 BACKGROUND

Oil and gas exploration and development in the Cook Inlet basin began with discoveries in the late 1950s and 1960s. Most of these activities have occurred on state lands and offshore in state waters. Exploration peaked around 1967 (MMS 2003). There were major discoveries offshore about this time with the McArthur River Field, which is ongoing and has produced over 1,000 billion cubic feet (ft^3) of gas and over 600 million barrels of oil. Of the 1.2 billion barrels produced, approximately 50 percent is from the McArthur River, 20 percent from Swanson River, and 30 percent from the other fields combined (MMS 2003).

Exploration and production has continued to decline in recent decades. The last commercial gas discoveries in Cook Inlet were the Cannery Loop and Pretty Creek gas fields discovered in 1979. While most of the emphasis has been in quest of oil, the last major oil discoveries were West McArthur River in 1990 with a reserve estimate of 3 million barrels and Tyonek Deep in 1991 with a reserve estimate of 25 million barrels. More recent discoveries by Forest Oil at Redoubt Shoal had an estimated production potential of 100 million barrels of oil. With these few exceptions, the overall production of Cook Inlet has declined sharply since the days of the "big discoveries" in the 1960s and oil production, which peaked at 230,000 barrels per day in 1970, declined to 33,000 barrels per day by 1997 (MMS 2003).

Presently seven oil fields on the Kenai Peninsula are producing about 30,000 barrels of oil per day. Seventeen gas fields currently produce more than 485 million ft^3 of gas per day. In 1999, nearly 11 million barrels of oil and 177 billion ft^3 of natural gas were produced from Cook Inlet gas fields. Offshore fields are presently tapped by 15 production platforms with three of these platforms shut in as a result of low production volumes. Fields on the Kenai Peninsula and offshore in Cook Inlet have produced a cumulative of 1.2 billion barrels of crude oil and 5.9 trillion ft^3 of natural gas.

Gas reserves in Cook Inlet in 1970 stood at about 8 trillion ft^3 and production was about 145 billion ft^3 per year. This excess of gas played against market conditions and there was little incentive to develop additional gas fields. Over time, these reserves have been slowly consumed. Some sources (Jepson, 2001) estimate that these developed reserves will be exhausted in about 2014. The reserve to production time for the gas industry in the lower 48 states is about 7 years with new resources being added at about the same rate. In the past, the overabundance of gas in the Cook Inlet basin has been a disincentive for exploration. Present economic conditions make gas profitable and a stimulus for increased exploration (Jepson, 2001).

In Cook Inlet, almost all of the currently known reserves are contained in what would be considered large or giant fields (more than 1 trillion ft^3). The next phase of exploration and development of Cook Inlet basin should see a greater number of smaller independent companies. The increased activity from independents is expected to drive exploration and development costs lower, especially for gas. More natural gas discoveries are expected as a result of the added exploration activity by independents in quest of the more abundant gas fields along with some oil discoveries. Most of the past oil and gas discoveries in the Cook Inlet basin are still producing and there are a few sites—all onshore—that presently are inactive and shut in, which include Albert Kaloa, Birch Hill, Pretty Creek, and West Fork. The North Trading Bay Unit, which is located offshore in Trading Bay, produced oil from 1967-1992 but now produces natural gas (MMS 2003).

2.2 EXPLORATION IN STATE AND FEDERAL WATERS

Although 5 lease sales have been held for tracts in federal waters within the Cook Inlet Outer Continental Shelf (OCS) Planning Area over the past 34 years, the lower Cook Inlet area is still considered to be relatively unexplored and to have potential undiscovered oil resources. In October 1977, Sale CI resulted in 88 leases being issued. In September 1981, Sale 60 resulted in 13 leases being issued. A re-offering sale, Sale RS-2, was held in August 1982, but no bids were received and no leases resulted from this sale. Sale 149, held in June 1997, resulted in 2 leases issued. Sale 191 was held in May 2004, and no bids were submitted. Two special interest Cook Inlet Sales, 211 and 219, were scheduled under the federal OCS 2007-2012 Leasing Program. On July 8, 2008, the Minerals Management Service (reorganized in 2011 as the Bureau of Ocean Energy Management, or BOEM) issued a Request for Information (RFI) for Cook Inlet Sale 211 and 3 comments were received, but no industry nominations identifying specific leasing interest. In 2008, MMS decided not to proceed with the Sale 211 presale process. On March 2, 2011, the decision to cancel Sale 219 was published in the Federal Register. There are currently no active federal OCS leases in Cook Inlet, but a Request for Information issued on March 27, 2012, confirmed interest in Lease Sale 244, scheduled during the 2012-2017 period.

Between 1978 and 1985, a total of 13 exploratory wells were drilled on federal leases in the Cook Inlet Planning Area, one of which was in Shelikof Strait, and all failed to find commercial quantities of oil or gas and have been permanently plugged and abandoned. Water depths for these exploration efforts ranged from 115-546 feet (ft) and all were drilled from temporary structures using jack-up rigs in shallower waters with semisubmersibles and drillships in the deeper waters.

State waters in Cook Inlet contain 16 production platforms, 12 of which are currently active. The State of Alaska currently has active oil and gas leases with 2 exploration operations underway in the 2012 drilling season. The most recent state oil and gas lease sale held in May 2012 included 197,795 acres.

Future exploration-well and delineation-well drilling could take place from a semisubmersible, jackup or other type of bottom-founded unit. Water depth will be a significant factor in selecting the appropriate drilling unit. In the southern portion of the Cook Inlet Outer Continental Shelf, most depths within the last lease sale, in 2004, ranged between 250 and 300 ft. Exploratory drilling throughout much of this area could be carried out by semisubmersible drilling units. Floating drilling units are also used when drilling in deep waters (USEPA 1993). In shallower waters, less than 200 ft deep, jackup rigs could be used. In the shallower portions of Cook Inlet, larger jackup rigs could remain onsite throughout the winter or spend the season in an ice-free port such as Homer in Kachemak Bay. In water less than 100 ft deep, a bottom-founded platform could be used. A more detailed discussion on the types of drilling rigs is provided below in Section 2.3.

The average total depth of exploration- and delineation-wells drilled in state waters between 2001 and 2009 was more than 8,600 ft (Stokes 2010). The drilling of each exploratory or delineation well would generate about 500 bbl of drilling fluids and approximately 600 dry tons of drill cuttings for disposal (BOEM 2012).

2.3 THE DRILLING PROCESS

Offshore drilling activities are divided into two phases: Exploratory drilling and development drilling. During the exploration phase of drilling operations, the goal is to identify areas within a formation that have the potential for hydrocarbon reserves and to delineate the size and extent of the oil or gas field. Exploration activities are most commonly conducted from mobile platforms. Once an area is determined to have recoverable hydrocarbons, the drilling operations move towards the development of the hydrocarbons. While these two business operations are strategically different, the drilling processes are similar (USEPA 1993). The proposed Cook Inlet Exploration general permits cover the discharges from exploration facilities only.

Exploration activities in Cook Inlet to date have been undertaken by drill ships, jack-up rigs and semi-submersible rigs Drill ships and ship-shaped barges are vessels equipped with drilling rigs that float on the surface of the water, and maintain their position by dynamic positioning and anchors on the seafloor. A jack-up rig consists of a drill rig attached to a barge. Once the barge reaches its desired location, support legs are attached and jacked downward to the sea floor. Once the legs reach the sea floor, the downward pressure of the jacking process lifts the barge out of the water. Semisubmersible rigs are mounted to a hull with adjustable ballast, allowing the hull to be raised or lowered within the water. The rig floats on top of the water when not in use. Once the hull is flooded, it sinks to a depth that allows the rig to remain stable against wave motion (USEPA 1993). All these drilling operations will result in similar if not identical types of discharges.

In the drilling process, preparing the first few hundred feet of a well is called “spudding in.” This typically requires a large diameter pipe, called the conductor casing, to be hammered, jetted, or placed on the seafloor, depending on the composition of the substrate (USEPA 1993). Once the conductor casing and surface casing are cemented in place, they guide the “drill string” down from the drill rig to the bore hole that will become the exploration well. To prevent well blowouts, blowout preventers (i.e., hydraulically operated high-pressure safety valves), are attached at or near the top of the well (termed “wellhead”) usually on the sea floor. The drill string consists of lengths of pipe threaded together to connect the torque-producing motor with the drill bit. During exploration drilling, drilling fluid (or drilling “mud”) is pumped down the annular space within the drill pipe and ejected from the drill bit into the well. The drilling fluids lift cuttings off the bottom of the well away from the drill bit, and circulate the cuttings back to the surface. Drilling fluids are composed of water-based, oil-based or synthetic-based materials (see discussion in Section 3). The drill cuttings and fluid are sent through a series of shaker tables and separators in order to remove the majority of solids and cuttings from the fluid.

The processed drilling fluid is then returned to a tank for reconditioning and reuse in the drilling process. Barite (barium sulfate) is added to drilling fluid as a weighting agent, which counteracts reservoir pressures and to prevent water from seeping into the well from the surrounding rock formation (Neff, 2008; USEPA 2000).

Only cuttings generated with water-based fluids or synthetic-based fluids are authorized for discharge under the proposed Cook Inlet Exploration general permits and are typically discharged to open water via a discharge pipe (outfall). During or following the drilling process, drilling fluids may need to be replaced or disposed of, which again is done in one of two methods. If the drilling fluids are water-based and free of oil and meet the effluent limitations established in the general permits, they can be disposed of through an outfall. If the fluids contain oil either because of their type (i.e., oil-based) or due to drilling operations, they would be placed in containers and disposed of onshore.

As the bore hole is drilled deeper, drilling is stopped periodically to run and cement additional sections or “strings” of steel casing. The casing keeps the walls of the bore hole from collapsing and reduces the probability that the drill string will become stuck. Other than the open hole that is being drilled (before each successive string of casing is run) the drill string operates within the casing. To keep each string of casing in place, cement is pumped down through the new string of casing, forced out of the open hole and back up the annular space outside of the casing, between it and the open hole, to fill the voids and keep the casing in place. Once the cement is set outside the casing, the drilling process continues. The initial casing may be on the order of 30 inches in diameter and is gradually stepped down in size as the hole deepens, each smaller string essentially hung from the larger string above it. The addition of casing string may be continued until final well depth is reached. If a stable formation is encountered in the process, drilling may be conducted “open hole” without a casing. At the end of the entire operation, cement is used to plug the well after it has been fully characterized and tested.

The discharge of drilling fluids and cuttings is an intermittent process, generally occurring only during active drilling operations. The discharge of cuttings ceases during the process of adding more pipe to the drill string or conducting cementing operations; in these times it is possible that drilling fluids continue to be discharged (whenever the drilling fluid is being circulated). The discharge of drilling fluids and cuttings happens for approximately 50 percent of the time the rig is “on station.”

On the rig, drainage waters from rainfall runoff from deck surfaces, and wash-down water generated during cleaning the deck are discharged via an outfall. Domestic gray water is generated from showers, laundry, and liquid galley wastes. Sanitary water is generated from treated sewage. These wastes may be combined and also discharged through one of several configurations. Desalination wastewater (brine), bilge water, and ballast water are wastewaters that are also discharged via the outfall. Solid food wastes are generally incinerated onboard the rig, while other solid wastes, such as trash and debris are stored and disposed of on land. Cooling water discharges may occur through the discharge pipe or shunted directly to the sea from the individual pieces of equipment associated with the cooling system. The design of the blowout preventer is such that the fluid used to open it after it has been closed for testing must be forced through the system and discharged at the unit itself.

2.4 SUMMARY

Oil and gas exploratory operations are conducted to determine the nature of potential hydrocarbon reserves. Drilling is the main activity during exploratory operations and the two major wastewater discharges from exploratory operations are drill cuttings and drilling fluids. Other discharges include deck drainage; sanitary waste; domestic waste; non-contact cooling water; desalination unit wastes; ballast water; bilge water; blowout preventer fluid; boiler blowdown; fire control system test water; excess cement slurry; and mud, cuttings and cement at the seafloor.

In general, exploratory facilities do not discharge waterflood waste water, produced water or well treatment fluids and the permits will not authorize these discharges.

3.0 DISCHARGED MATERIALS, ESTIMATED QUANTITIES AND MODELED BEHAVIOR

This section discusses the composition and quantity of potential discharges authorized by the proposed Cook Inlet Exploration general permits to the Area of Coverage described in Section 1.0. The information presented here is also reflected in EPA's *Final Development Document for Effluent Limitation Guidelines and New Source Performance Standards for the Offshore Subcategory of the Oil and Gas Extraction Point Source Category* (USEPA 1993), and information from the most recently drilled exploration wells in Cook Inlet. This section also presents the results of modeling that estimates dilution and settling of solids under a variety of receiving water conditions.

3.1 AUTHORIZED DISCHARGES

Offshore oil and gas exploration activities are generally characterized as short-term at any particular location and typically involve only a small number of wells. These activities, however, do generate numerous waste streams that are commonly discharged from the drilling rig into the ocean. These waste streams are related to the drilling process, equipment maintenance and personnel housing, and include:

- Discharge 001 – Drilling Fluids and Drill Cuttings
- Discharge 002 – Deck Drainage
- Discharge 003 – Sanitary Wastes
- Discharge 004 – Domestic Wastes
- Discharge 005 – Desalination Unit Wastes
- Discharge 006 – Blowout Preventer Fluid
- Discharge 007 – Boiler Blowdown
- Discharge 008 – Fire Control System Test Water
- Discharge 009 – Non-Contact Cooling Water
- Discharge 010 – Uncontaminated Ballast Water
- Discharge 011 – Bilge Water
- Discharge 012 – Excess Cement Slurry
- Discharge 013 – Mud, Cuttings, Cement at the Seafloor

The proposed Cook Inlet Exploration general permits authorize discharges of these waste streams to Cook Inlet, which are discussed further below. Table 3.4, at the end of this section, lists anticipated discharge quantities based on assumptions of the numbers of wells to be drilled under the proposed Cook Inlet Exploration general permits.

3.1.1 Drill Cuttings

Drill cuttings are rock particles broken loose by the drill bit and carried to the surface by drilling fluids that circulate through the borehole. The cuttings are composed of the naturally occurring solids found in subsurface geologic formations and, to a much lesser extent, bits of cement used during the drilling process. Cuttings are separated from the drilling fluids by a shale shaker and other solids control equipment. Drilling fluids are circulated back down the borehole.

The cuttings are discharged to the sea through an outfall. This discharge may contain small amounts of drilling fluids that remained adhered to the surface of the cuttings after the solids separation process. The main source of pollutants in drill cuttings are associated with the drilling fluids that adhere to the rock particles (USEPA 2000). Therefore, based on the effluent limitations guideline (ELGs) for Best Available Technology Economically Achievable (BAT), Best Conventional Pollutant Control Technology (BCT), Best Practicable Control Technology Currently Available (BPT), the proposed Cook Inlet Exploration general permits, like the existing general permit, apply the same limits to the drill cuttings discharges as the drilling fluid discharges.

The proposed Cook Inlet Exploration general permits would authorize the discharge of drill cuttings generated using water-based and synthetic-based drilling fluids to the territorial seas and federal waters (see Figure 1). The use of synthetic-based fluids is a type of pollution prevention technology because the drilling fluids are not disposed of through bulk discharge at the end of drilling. Instead, the drilling fluids are brought back to shore and refurbished so that they can be reused. In addition, drilling with synthetic based fluids allows operators to drill a slimmer well and results in less erosion of the well during drilling than when water-based fluids are used. Thus, the volume of drill cuttings that are discharged is reduced. The proposed Cook Inlet Exploration general permits would require permittees to remove synthetic-based drilling fluids from the drill cuttings prior to discharge, which is not required when water-based fluids are used.

While the ELGs do not specify the specific types of synthetic-based fluid, the ELGs include limits for sediment toxicity and biodegradation, which encourage operators to use less toxic fluids with a higher biodegradation rate. Because drill cuttings are allowed to be discharged when using synthetic-based drilling fluids, the proposed Cook Inlet NPDES general permits contain the following limits and should specify the analytical methods for synthetic-based drilling fluids:

- For stock synthetic fluids prior to combination with other components of the drilling fluid system, the proposed Cook Inlet Exploration general permits impose limits on polynuclear aromatic hydrocarbons (PAHs), sediment toxicity (10-day), and biodegradation rate;
- Combined fluid components are limited for formation oil contamination, measured using gas chromatography/mass spectrometry (GC/MS); and
- Drilling fluids that adhere to drill cuttings are limited for sediment toxicity (4-day), and formation oil contamination as measured by either a reverse phase extraction test or GC/MS

3.1.2 Drilling Fluids

The term “drilling fluids” refers to a suspension of solids and dissolved materials in a water, oil, or synthetic base, and may also be referred to as “drilling muds.” This document uses the term “drilling fluids” throughout but notes that “drilling muds” may be used in technical documents and materials cited as references. For the proposed Cook Inlet Exploration general permits, there is no significant difference between these terms.

> **Drilling fluids** are an *emulsion*. An emulsion is a mixture in which one liquid, termed the *dispersed* phase, is uniformly distributed (usually as minute globules) in another liquid called the *continuous phase*.

The proposed Cook Inlet Exploration general permits only authorize the discharge of water-based drilling fluids. Operators may choose to use oil-based or synthetic-based fluids during exploration activities, but those drilling fluids cannot be discharged under these permits and the discharge prohibition extends to all cuttings generated with oil-based drilling fluids. Since the discharge of oil- and synthetic-based fluids and cuttings associated with oil-based fluids is prohibited, these fluids are not discussed further. A detailed discussion of oil- and synthetic-based fluids can be found in the *2006 Final Ocean Discharge Criteria Evaluation of the Cook Inlet NPDES General Permit for Oil and Gas Exploration* (USEPA 2006).

Drilling fluids are specifically formulated for each well to meet unique physical and chemical requirements and to perform specific functions. The well's location, depth, rock type and other conditions are all considered to develop a drilling fluid with the appropriate viscosity, density, sand content, and gel strength. During exploratory drilling, fluids are pumped down the borehole and circulated back to the surface, and are designed to perform one or more of the following primary functions:

- Remove cuttings and transport them to the surface;
- Cool and clean the drill bit;
- Lubricate the drill string;
- Maintain the stability of uncased sections of the borehole; and/or
- Counterbalance formation pressure to prevent formation fluids (i.e., oil, gas and water) from entering the well prematurely (Berger and Anderson, 1992; Sounders, 1998).

Because the costs of transporting and formulating drilling fluids, they are re-circulated and reused to the extent feasible during the drilling process. The operator may need to discharge drilling fluids under a variety of circumstances, including fouling of the drilling fluid over time, significant changes in the required type of fluid, changes in drilling phases, and well completion/closure. An important factor governing the need to discharge fluids is the constraint of solids storage on the vessel. The slurry tanks are sized such that the vessel integrity is maintained, but storage capacity may not be sufficient to store and reuse all drilling fluids throughout the well-drilling process.

3.1.2.1 Water-Based Drilling Fluids (WBF)

In WBFs, water is the suspending medium for solids and is the continuous phase. These fluids are composed of approximately 50 to 90 percent water by volume, with additives comprising the rest. WBFs are used most frequently because they are the least expensive, although they are not always the most effective in a given situation. WBFs have limited lubricity and cause reactivity with some shale formations. In deep holes or high-angle directional drilling, WBFs are not able to provide sufficient lubricity to avoid sticking of the drill pipe. Reactivity with clay shale can cause destabilization of the borehole.

There are eight generic types of WBFs (USEPA 1993).

1. Potassium/polymer fluids are inhibitive fluids because they do not change the formation after it is cut by the drill bit. This fluid is used in soft formations such as shale where sloughing may occur.

2. Seawater/lignosulfonate fluids are inhibitive fluids that maintain viscosity by binding lignosulfonate cations onto the broken edges of clay particles. This fluid is used to control fluid loss and to maintain the borehole stability. This type of fluid can be easily altered to address complicated drilling conditions, like high temperature in the geologic formation.

3. Lime (or calcium) fluids are inhibitive fluids that change viscosity as calcium binds clay platelets together to release water. This fluid can maintain more solids and are used in hydratable, sloughing shale formations.

4. Nondispersed fluids are used to maintain viscosity, to prevent fluid loss, and to provide improved penetration, which may be impeded by clay particles in dispersed fluids.

5. Spud fluids are non-inhibitive fluids that are used in approximately the first 300 meters of drilling. This is the most basic fluid mixture which contains mostly seawater and few additives.

6. Seawater/freshwater gel fluids are inhibitive fluids used in early drilling to provide fluid control, shear thinning, and lifting properties for removing cuttings from the hole. Prehydrated bentonite is used in both seawater and freshwater fluids and attapulgite is used in seawater when fluid loss is not a concern.

7. Lightly treated lignosulfonate freshwater/seawater fluids resemble seawater/ lignosulfonate liquids except their salt content is less. The viscosity and gel strength of this fluid are controlled by lignosulfonate or caustic soda.

8. Lignosulfonate freshwater fluids are similar to the fluids at #2 and #7 above, except the lignosulfonate content is higher. This fluid is used for higher temperature drilling.

3.1.2.2 Composition and Additives

The composition of drilling fluids can be adjusted over a wide range from one borehole to the next, as well as during the course of drilling a single hole when encountering different formations. In addition to the variability among WBFs depending on the character of the borehole, additives can be adjusted depending on particular needs within the drilling process. **Error! Reference source not found.** shows several common WBF formulations that have been used in offshore drilling operations in the past.

The list below presents some of the more common additives and is followed by a more detailed discussion of some of the additives.

1. Weighting materials, primarily barite (barium sulfate), are commonly used to increase the density of the drilling fluid in order to equilibrate the pressure between the borehole and formation when drilling through particularly pressurized zones.
2. Corrosion inhibitors such as iron oxide, aluminum bisulfate, zinc carbonate, and zinc chromate protect pipes and other metallic components from acidic compounds encountered in the formation.
3. Dispersants, including iron lignosulfonates, break up solid clusters into small particles so they can be carried by the fluid.
4. Flocculants, primarily acrylic polymers, cause suspended particles to group together so they can be removed from the fluid at the surface.

5. Surfactants, like fatty acids and soaps, are used to defoam and emulsify the drilling fluid.
6. Biocides, typically organic amines, chlorophenols, or formaldehydes, kill bacteria that may produce toxic hydrogen sulfide gas.
7. Fluid loss reducers include starch and organic polymers. These limit the loss of drilling fluid to under-pressurized or high-permeability formations (USEPA 1987).

Table 3-1. Generic Fluid Formulations (USEPA 1985)

Seawater/Potassium/Polymer Fluid		Seawater/Freshwater Gel Fluid	
Components	**lb/bbl**	**Components**	**lb/bbl**
KCl	5 – 50	Attapulgite or Bentonite Clay	10 – 50
Starch	2 – 12	Caustic	0.5 – 3
Cellulose Polymer	0.25 – 5	Cellulose Polymer	0 – 2
XC Polymer	0.25 – 2	Drilled Solids	20 – 100
Drilled Solids	20 – 100	Barite	0 – 50
Caustic	0.5 – 3	Soda Ash/Sodium Bicarbonate	0 – 2
Barite	0 – 450	Lime	0 – 2
Seawater	As Needed	Seawater/Freshwater	As Needed
Seawater Lignosulfonate Fluid		**Lime Fluid**	
Components	**lb/bbl**	**Components**	**lb/bbl**
Attapulgite or Bentonite	10 – 50	Lime	2 – 20
Lignosulfonate	2 – 15	Bentonite	10 – 50
Lignite	1 – 10	Lignosulfonate	2 – 15
Caustic	1 – 5	Lignite	0 – 10
Barite	25 – 450	Barite	25 – 180
Drilled Solids	20 – 100	Caustic	1 – 5
Soda Ash/Sodium Bicarbonate	0 – 2	Drilled Solids	20 – 100
Cellulose Polymer	0.25 – 5	Soda Ash/Sodium Bicarbonate	0 – 2
Seawater	As Needed	Freshwater	As Needed
lb/bbl = pounds per barrel			

3.1.2.2.1 Barite

Barite is a chemically inert mineral that is heavy and soft, and is the principal weighting agent in WBFs. Barite is composed of over 90 percent barium sulfate, which is virtually insoluble in seawater, and is used to increase the density of the drilling fluid to control formation pressure (Perricone 1980). Quartz, chert, silicates, other minerals, and trace levels of metals can also be present in barite.

The presence of potentially toxic trace elements in drilling fluids and adherence to cuttings is a concern. Barite is known to contain trace contaminants of several toxic heavy metals such as mercury, cadmium, arsenic, chromium, copper, lead, nickel, and zinc (USEPA 2000). In order to control the concentration of heavy metals in drilling fluids, EPA promulgated regulations applicable to the offshore subcategory of the oil and gas industry in 1993 (40 CFR Part 435, Subpart A) requiring that stock barite meet the criteria limits of 3 milligrams per kilogram (mg/kg) for cadmium and 1 mg/kg for mercury. Table 3-2 presents the metals concentrations in barite that were the basis for the cadmium and mercury limitations in the offshore subcategory.

Table 3-2. Metals Concentrations in Barite Used in Drilling Fluids	
Metal	**“Clean” Barite Concentrations (mg/kg)**
Aluminum	9,069.9
Antimony	5.7
Arsenic	7.1
Barium	359,747.0
Beryllium	0.7
Cadmium	1.1
Chromium	240.0
Copper	18.7
Iron	15,344.3
Lead	35.1
Mercury	0.1
Nickel	13.5
Selenium	1.1
Silver	0.7
Thallium	1.2
Tin	14.6
Titanium	87.5
Zinc	200.5
Source: USEPA 1993; Table XI-6	

3.1.2.2.2 Clay

Clay compounds are added to drilling fluids to control certain physical properties, such as fluid loss, viscosity and yield point, and eliminate borehole problems. The most commonly used commercial clay is sodium montmorillonite. Bentonite is another common additive used to increase the fluid’s viscosity and gel strength, which increases the carrying capacity for solids removal from the borehole. Bentonite also greatly improves the filtration and filter cake properties of the fluid (Lyons 2009). The concentration of bentonite in drilling fluid systems is usually 5 to 25 lb/bbl. In the presence of concentrated brine, or formation waters, attapulgite or sepiolite clays (10 to 30 lb/bbl) are substituted for bentonite (Perricone 1980).

3.1.2.2.3 Lignosulfonate

Lignosulfonate is used to control viscosity in drilling fluids by acting as a thinning agent or deflocculant for clay particles. Concentrations in drilling fluid range from 1 to 15 lb/bbl. It is made from the sulfite pulping of wood chips used to produce paper and cellulose. Ferrochrome lignosulfonate, the most commonly used form of lignosulfonate, is made by treating lignosulfonate with sulfuric acid and sodium dichromate. The sodium dichromate oxidizes the lignosulfonate and cross linking occurs. Hexavalent chromium supplied by the chromate is reduced during reaction to the trivalent state and complexes with the lignosulfonate. At high downhole temperatures, the chrome binds onto the edges of clay particles and reduces the formation of colloids. Ferrochrome lignosulfonate retains its properties in high soluble salt concentrations and over a wide range of alkaline pH (USEPA 1993).

3.1.2.2.4 Caustic Soda

Sodium hydroxide is used to maintain the filtrate pH between 9 and 12. A pH of 9.5 provides for maximum deflocculation and keeps the lignite in solution. A more basic pH lowers the corrosion rate and provides protection against hydrogen sulfide contamination by limiting microbial growth (Lyons 2009).

3.1.2.2.5 Spotting Compounds

Spotting compounds are used to help free stuck drill strings. A concentrated slug or "pill" of the spotting agent is pumped downhole and up the annular space between the borehole and drill pipe. After working to free the stuck pipe the pill is then pumped back to the surface. Some of these (e.g., vegetable oil or fatty acid glycerol) are easily broken down in the environment. The most effective and, consequently, most frequently used compounds are oil-based (diesel or mineral oil). Mineral oils can contribute potentially toxic organic pollutants to drilling fluids to which they are added. Data show that the concentration of organic pollutants in the drilling fluids is roughly proportional to the amount of mineral oil added. The proposed Cook Inlet Exploration general permits do not authorize the discharge of drilling fluids or cuttings that are contaminated with diesel fuel. In addition, the permit authorizes the discharge of residual amounts of mineral oil pills provided that certain precautionary measures are taken to minimize contamination of the drilling fluids .

3.1.2.2.6 Lubricants

Lubricants are added to the drilling fluid when high torque conditions are encountered on the drill string. These can be vegetable, paraffinic, or asphaltic-based compounds such as Soltex. Mineral oil-based lubricants may contribute to organic pollutant loading and, like spotting fluids, are not authorized for discharge under the proposed Cook Inlet Exploration general permits.

3.1.2.2.7 Zinc Carbonate

Zinc carbonate is used as a sulfide scavenger when formations containing hydrogen sulfide are expected to be encountered during drilling. The zinc sulfide and unreactive zinc compounds are discharged with the drilling fluid, thus contributing to the overall loading of zinc when they are used. While the potential need exists, most drilling activities do not encounter conditions that warrant the addition of sulfide scavengers (Lyons and Plisga 2005).

3.2 OTHER DISCHARGES

In addition to drilling fluids and drill cuttings, the proposed Cook Inlet Exploration general permits authorize 12 other exploration waste streams. Note that the discussion for sanitary and domestic wastewater is combined in the discussion below.

3.2.1 Deck Drainage

Deck drainage refers to any wastewater generated from platform washing, deck washing, spillage, rainwater, and runoff from curbs, gutters, and drains, including drip pans and wash areas. This type of drainage could include pollutants such as detergents used in platform and equipment washing, oil, grease, and drilling fluids spilled during normal operations.

When water from rainfall or from equipment cleaning comes in contact with oil-coated surfaces, the water becomes contaminated and must be treated and disposed. Oil and grease are the primary pollutants identified in the deck drainage waste stream (USEPA 1993). In addition to oil, various other chemicals used in drilling operations may be present in deck drainage. These chemicals may include drilling fluids, ethylene glycol, lubricants, fuels, biocides, surfactants, detergents, corrosion inhibitors, cleaners, solvents, paint cleaners, bleach, dispersants, coagulants, and any other chemical used in the daily operations of the facility (Dalton et al. 1985).

Untreated deck drainage can contain oil and grease in quantities ranging from 12 to 1,310 milligrams per liter (mg/L). However, the proposed Cook Inlet Exploration general permits do not allow the discharge of deck drainage unless it complies with the effluent limitations specified in the permits. Ranges for other pollutant quantities in untreated deck drainage are provided in Table 3-3.

USEPA (1993) determined that the best practicable control technology currently available for treatment of deck drainage is a sump and skim pile system for treating deck drainage. Oil and water are gravity-separated in the sump, and the oil is sent off-site to an oil treater. After treatment in an oil water separator, clean water is discharged, and oily water is stored onboard until transferred to an approved treatment and disposal site. The permit requires that deck drainage contaminated with oil and grease is processed through an oil water separator prior to discharge and also prohibits the discharge of free oil in deck drainage discharges.

3.2.2 Sanitary and Domestic Waste

While some platforms discharge sanitary and domestic wastes separately, many combine these waste streams prior to discharge. Therefore, this section will discuss sanitary waste, domestic waste and the combined waste. Sanitary waste is human body waste discharged from toilets and urinals and treated with a marine sanitation device (MSD). The discharge consists of secondary treated chlorinated effluent. Domestic waste (gray water) refers to materials discharged from sinks, showers, laundries, safety showers, eyewash stations, and galleys. Gray water can include kitchen solids, detergents, cleansers, oil and grease. Domestic waste includes solid materials such as paper and cardboard which must be disposed of properly. Domestic waste is incinerated, reused to make drilling fluid, or discharged directly into receiving waters.

The volume of sanitary wastes varies widely with time, occupancy, platform characteristics and operational situation. Pollutants of concern in sanitary waste include biochemical oxygen demand (BOD), total suspended solids (TSS), fecal coliform bacteria, and residual chlorine.

Table 3-3. Pollutant Concentrations in Untreated Deck Drainage (USEPA 1993)		
	Pollutant	**Range**
Conventional (mg/L)	pH BOD TSS Oil and Grease	6.6-6.8 <18-550 37.2-220.4 12-1,310
Nonconventional (µg/L)	Temperature (°C) TOC (mg/L) Aluminum Barium Boron Calcium Cobalt Iron Magnesium Manganese Molybdenum Sodium Tin Titanium Vanadium Yttrium	20-32 21-137 176-23,100 2,420-20,500 3,110-19,300 98,200-341,000 <20 830-81,300 50,400-219,000 133-919 <10-20 $151x10^4$-$568x10^4$ <30 4-2,030 <15-92 <2-17
Priority Metals (µg/L)	Antimony Arsenic Beryllium Cadmium Chromium Copper Lead Mercury Nickel Selenium Silver Thallium Zinc	<4-<40 <2-<20 <1-1 <4-25 <10-83 14-219 <50-352 <4 <30-75 <3-47.5 <7 <20 2,970-6,980
Priority Organics (µg/L)	Acetone Benzene m-Xylene Methylene chloride N-octadecane Naphthalene o,p-Xylene Toluene 1,1-Dichloroethene	ND-852 ND-205 ND-47 ND-874 ND-106 392-3,144 105-195 ND-260 ND-26

* Ranges for four samples, two each, at two of the three facilities in the three-facility study conducted by EPA. The study was conducted over four days in 1989 at three oil and gas production facilities that used granular filtration for treatment of produced water: Thums Long Beach Island Grissom, Shell Western E&B Inc. – Beta Complex, and Conoco's Maljamar Oil Field. (USEPA 1993).

ND=not detected

The proposed Cook Inlet Exploration general permits allow the discharge of sanitary and domestic wastes provided effluent limitations are met. Sanitary wastewater must be treated with an approved MSD prior to discharge, while domestic (gray) wastewater may be discharged directly or after chlorination.

Permittees indicate that sanitary and domestic wastewaters are discharged via the disposal caisson, and that any non-hazardous combustible domestic waste is incinerated on-board. Non-combustible domestic solid waste, such as metals and plastics are stored and transferred to an approved landfill or other approved site.

3.2.3 Desalination Unit Waste

Desalination unit waste is residual high-concentration brine, associated with the processes (distillation or reverse osmosis units) used in creating freshwater from seawater. The concentrate is similar to sea water in chemical composition; however, anion and cation concentrations are higher. Discharges from desalination units occur via the disposal caisson and may vary greatly in volume depending on the freshwater needs of the rig.

The proposed Cook Inlet Exploration general permits prohibit the discharge of free oil in this waste stream. If a sheen is detected using a sheen test, as described in the permits, the waste stream is not permitted to be discharged.

3.2.4 Blowout Preventer Fluid

As previously described, the blowout preventer is a device typically located below the sea floor designed to maintain the pressure in the well that cannot be controlled by the drilling fluid. Fluid used to operate the blowout preventer may be discharged in small quantities (less than 42 bbl/well or approximately 7 bbls per testing event) when the blowout preventer is actuated on the hydraulic equipment. Testing of the blowout preventer device must be conducted periodically (typically on a weekly basis). In the case of Furie Operating Alaska LLC (Furie), during drilling of their Kitchen Lights Unit wells BOP equipment was tested bi-weekly and in accordance with American Petroleum Institute (API) Recommended Practice No. 53 and Alaska Oil and Gas Conservation Commission (AOGCC). The primary constituents of blowout preventer fluid are oil (vegetable or mineral) or seawater mixed with an antifreeze solution (ethylene glycol).

The proposed Cook Inlet Exploration general permits allow the discharge of this waste stream, but requires that no free oil is detected using a sheen test, as described in the permits.

3.2.5 Boiler Blowdown

Boiler blowdown is the discharge of water and minerals drained from boiler drums to minimize solids build-up in the boiler.

The proposed Cook Inlet Exploration general permits require reporting of the total discharge volume of this waste stream and an inventory of the type and quantity of biocides or other chemicals that are added to the boiler system. Discharges of boiler blowdown water that contain no free oil as determined by the visual sheen test are authorized under the permit.

3.2.6 Fire Control System Test Water

Fire control system test water is sea water that is released during the training of personnel in fire protection, and the testing and maintenance of fire protection equipment on the platform. Fire control system test water discharges occur as an overboard discharge. This test water may be treated with a biocide.

As a result of the limited quantitative data available on biocide concentrations in Alaskan offshore discharges, the proposed Cook Inlet Exploration general permits include a requirement to report the quantities of biocide added to fire control system test water and to reporting of the total discharge volume of this waste stream, including any biocides added to the system.

3.2.7 Non-Contact Cooling Water

Non-contact cooling water is sea water that is used for non-contact, once-through cooling of various pieces of machinery (e.g., power generators) on the drilling rig. Depending on the volume of water-based drilling fluids discharged, non-contact cooling water might comprise the majority of the volume of the discharges that would be released under the proposed Cook Inlet Exploration general permits. The volume of non-contact cooling water depends on the configuration of heat exchange systems on the drilling rig. Some systems use smaller volumes of water that are heated to a greater extent, resulting in a higher temperature differential between waste water and receiving water. Other systems use larger volumes of water to cool equipment, resulting in a smaller difference between the temperature of waste water and receiving water. Depending on the heat exchanger materials and the system design, biocides or oxidizing agents may be needed to control biofouling on condenser tubes and intake and discharge conduits.

As a result of the limited quantitative data available on biocide concentrations in Alaskan offshore discharges, the proposed Cook Inlet Exploration general permits include a requirement to report the quantities of biocide added to non-contact cooling water and to implement best management practices to minimize their use.

Discharges occur via numerous overboard outfalls from the ship. A small volume of non-contact cooling water is typically used to dilute discharges of drill cuttings.

3.2.8 Ballast Water

Ballast water is seawater added or removed to maintain the proper ballast floater level and ship draft. If no free oil is detected using a sheen test, as described in the permits, ballast water can be discharged without treatment. If ballast water is contaminated with oil, the proposed Cook Inlet Exploration general permits require the waste stream to be treated through the oil water separator prior to discharge via the disposal pipe.

3.2.9 Bilge Water

Bilge water is seawater that collects in the lower internal parts of the drilling vessel hull. It becomes contaminated with oil and grease and with solids such as rust when it collects at low points in the bilges.

The proposed Cook Inlet Exploration general permits require treatment through the oil-water separator prior to discharge at the disposal pipe.

3.2.10 Excess Cement

The discharge of excess cement slurry at the discharge pipe will result from equipment washdown after cementing operations at the seafloor surface. Excess cement slurry is discharged in small quantities during installation of the drill casing, and varies based on drilling conditions, the casing and testing program in effect. The proposed Cook Inlet Exploration general permits require reporting of the total discharge volume of this waste stream and require no discharge of free oil.

3.2.11 Muds, Cuttings, Cement at Seafloor

Drilling fluid, cuttings, and cement are materials discharged at the seafloor in the early phases of drilling operations, such as spudding the well or during cementing operations before the casing is set, and during well abandonment and plugging. This discharge also results from the marine riser disconnect on drill ships and semi-submersibles. Aside from cement, cement extenders, accelerators, and dispersants are the main chemicals added to this discharge.

The proposed Cook Inlet Exploration general permits require reporting of the total discharge volume of this waste stream and require that there is no discharge of free oil in the discharge of drilling fluid, cuttings and cement at the seafloor.

3.2.12 Chemically Treated Sea Water Discharges

Operators use a broad range of chemicals to treat seawater and freshwater used in offshore operations. The available literature shows that more than twenty biocides are commonly used. These include derivations of aldehydes, formaldehyde, amine salt, and other compounds. The toxicity of these compounds to marine organisms as measured with a 96-hour LC_{50} (lethal concentration to 50% of test organisms) test is reported to range from 0.4 mg/L to greater than 1000 mg/L. Scale inhibitors are also used to treat seawater and freshwater. The scale inhibitors commonly used are amine phosphate ester and phosphonate compounds. Scale inhibitors are generally less toxic to marine life than biocides with 96-hour LC_{50} concentrations shown to be from 1,676 mg/L to greater than 10,000 mg/L. 96-hour LC_{50} values for corrosion inhibitors were reported to range from 1.98 mg/L to 1050 mg/L.

The 2007 Cook Inlet NPDES general permit used generic BPJ (Best Professional Judgement)-based limits, based on available technology, to regulate chemically treated sea water and fresh water discharges, rather than attempting to limit the discharge of specific biocides, scale inhibitors and corrosion inhibitors. The proposed Cook Inlet NPDES general permits retain these limitations.

Many of the chemicals normally added to seawater or freshwater, especially biocides, have manufacturer’s recommended maximum concentrations or EPA product registration labeling. In addition, information obtained from offshore operators demonstrates that it is unnecessary to use any of the chemical additives or biocides in concentrations greater than 500 mg/L.

Concentrations of treatment chemicals in discharges of sea water or fresh water are limited in the proposed Cook Inlet Exploration general permits to the most stringent of the following EPA requirements:

- The maximum concentrations and any other conditions specified in the EPA product registration labeling if the chemical additive is an EPA-registered product.
- The maximum manufacturer's recommended concentration when one exists.
- A maximum concentration of 500 mg/L.

The proposed Cook Inlet Exploration general permits contain BCT limits prohibiting the discharge of free oil for chemically-treated seawater and freshwater discharges and also contains a visual sheen monitoring requirement for miscellaneous discharges after it is run through an oil-water separator.

The proposed Cook Inlet Exploration general permits require reporting of the total discharge volume of this waste stream and require that there is no discharge of free oil in the discharge.

3.3 ESTIMATED DISCHARGE QUANTITIES

Through 1985, 13 exploration wells were drilled in federal waters of the Cook Inlet (BOEM 2012). Since 2002, there have been a total of 8 wells drilled at the Osprey Platform (Redoubt Shoal Field in Alaska state waters), but two of these were for the injection of water to add pressure in the reservoir and boost oil production (Morris News Service 2011). Based on the sporadic history of exploratory drilling, the number of exploration wells that will be drilled within the area of coverage of the proposed Cook Inlet Exploration general permits is unknown and the volumes of various discharges must be estimated.

The discharge rate of drill cuttings and drilling fluids during well drilling operations is variable. The volume of rock cuttings produced from drilling is primarily a function of the depth of the well and the diameter of the bore hole (USEPA 2000). USEPA (1987) estimated that between 0.2 barrels and 2.0 barrels (8.4 to 84.0 gallons) of total drilling waste are produced for each vertical foot drilled. During exploratory-drilling operations, bulk drilling fluid, usually about 100–200 barrels at a time, is discharged several times during the drilling of a well, when the composition of the drilling fluid has to be changed substantially, or when the volume exceeds the capacity of the fluid tanks. Washed drill cuttings and a small volume of drilling fluid solids are continuously discharged during drilling operations; the discharge rate varies from about 25 to 250 barrels per day (MMS 2003). The proposed Cook Inlet Exploration general permits require that the following effluent limitations be met for depth-dependent discharges of water-based fluids and cuttings:

- No discharge at 0 to 10 m (33 ft)
- 500 barrels (bbl)/hour (79 cubic meters [m^3]) at > 10 to 20 m (>33 – 66 ft)
- 750 bbl/hour (119 m^3) at > 20 to 40 m (>66 – 131 ft)
- 1,000 bbl/hour (159 m^3) at > 40 m (> 131 ft)

The actual number of exploratory wells that will be drilled in the Area of Coverage during the 5-year term of the Cook Inlet general permits is not known; therefore, the volumes of various discharges must be estimated. EPA estimates the potential drilling of up to 12 wells in federal waters during the term of the permit as a high-end estimate according to existing information (BOEM 2012). The State of Alaska currently has two active exploration operations underway. Only two exploratory wells have been drilled in state waters during the previous permit. Furie has completed two exploratory gas wells in the Kitchen Lights Unit. The first well was completed to 15,000 ft over two seasons and took a total of 21 days. The second well took a total of 17 days and completed to 12,000 ft (Webb 2013).

Discharge estimates per well were derived by EPA using the NOI information submitted by Furie. In the NOI information submitted by Furie, Discharges 002, 003, 004, 005, 006, 007, 009, 011, and 012 were reported as barrels per day. EPA has used 20 days as the average number of days to drill an exploratory well and included these numbers in parentheses in Table 3-4, below. The volumes presented provide a reasonable estimate of potential volumes that could be discharged for each waste stream during the 5-year term of the Cook Inlet general permit. The estimated average and maximum discharge quantities are summarized in Table 3-4, below. Although these discharge numbers are representative of exploration activities in an area not covered by this ODCE, EPA has chosen to use them as they represent the most recent discharge data in the Cook Inlet.

Table 3-4. Estimated discharge quantities

Discharge	Average Discharge Quantities (bbls/well) based on Furie's NOI	Maximum Discharge Quantities for 12 wells (bbls/well)
Drill Cuttings (001)	35,000 bbls/well	420,000 bbls
Drill Fluids (001)	30,000 bbls/well	360,000 bbls
Deck Drainage (002)	100 bbls/day (2,000 bbls/well)	24,000 bbls
Sanitary Waste (003)	100 bbls/day (2,000 bbls/well)	24,000 bbls
Domestic Waste (004)	500 bbls/day (10,000 bbls/well)	120,000 bbls
Desalination Brine (005)	200 bbls/day (4,000 bbls/well)	48,000 bbls
BOP Fluid (006)	42 bbls /well	840 bbls
Boiler Blowdown (007)	100 bbls/day (2,000 bbls/well)	24,000 bbls
Fire Control Test Water (008)	2,000 bbs/test (no regular discharge- only in case of fire, blowout, or system test)	2,000 bbls/test
Non-Contact Cooling Water (009)	50,000 bbls/day (1,000,000 bbls/well)	12,000,000 bbls
Ballast water (010)	1.8 MM bbls/preload cycle	22,000,000 bbls (if 12 potential wells are jack-up rigs)
Bilge Water (011)	10 bbls/day (200 bbls/well)	2,400 bbls
Excess Cement (012)	200 bbls/day (4,000 bbls/well)	48,000 bbls
Fluids and Cuttings at Seafloor (013)	35,000 bbls/well	420,000 bbls

4.0 DESCRIPTION OF THE EXISTING PHYSICAL ENVIRONMENT

4.1 CLIMATE AND METEOROLOGY

The Cook Inlet area is characterized by three climate zones: the maritime zone, continental zone, and transition zone (Alaskool 2004 in ADNR 2009). *Cook Inlet areawide oil and gas lease sale: Final finding of the Director)*. In the maritime zone areas, which encompass the coast and islands, annual precipitation averages about 60 inches. Mean maximum temperatures in the summer are in the upper 50s, and low means during winter are in the low 20s. Offshore winds average 12-18 knots, with winter extremes of 50-75 knots (Alaskool 2004).

In the lower Cook Inlet region, the climate is transitional from a maritime to a continental climate. Generally, lower Cook Inlet is a maritime climate, wetter and warmer than the upper Cook Inlet region, which exhibits some continental climatic features—that is, the upper Cook Inlet region is drier and cooler than the lower (MMS 2003). Areas further from the coast may have continental zone characteristics, with annual precipitation from 10-15 inches, mean maximum summer temperatures in the mid- to upper 60s, and mean lows in the winter ranging from -10 to -30 degrees. Surface winds tend to be lighter compared to coastal maritime areas.

Overland and Heister (1980) define six Gulf of Alaska weather types that influence lower Cook Inlet. The Aleutian low-pressure center occurs most often. The Aleutian Low, a semi-permanent low-pressure system over the Pacific Ocean, has a strong effect on the climate in the area. As this low-pressure area moves and changes in intensity, it brings storms with wind, rain, and snow (Wilson and Overland 1986). The other weather types are the low-pressure center over central Alaska; the stagnating low off the Queen Charlotte Islands; and the Pacific Anticyclone, also known as the East Pacific High (Overland and Hiester 1980). Generally, winter is characterized by an inland high-pressure cell with frequent storm progressions from the west along the Aleutian chain. During summer, a low-pressure cell is over the inland area, with fewer storms (MMS 2003). Spring and fall are characterized by a transition between these generalized patterns (Macklin 1979).

Precipitation decreases from south to north along the inlet. Kodiak is the wettest, and Anchorage is drier (MMS 2003). Cook Inlet precipitation (SAIC 2001) averages less than 20 percent of that measured on the Gulf of Alaska side of the Kenai Mountains (NCG 2001). Homer, Kenai, and Anchorage all have substantially less precipitation than Kodiak due to the sheltering or rain shadow effect of the Kenai Mountains. Homer averages about 25.5 inches of precipitation annually, and Anchorage averages about 15.7 inches. The wettest months are September and October, with the relatively dry conditions in April through July. In the northern inlet, precipitation usually falls as snow from October to April and as rain the rest of the months. Farther south in the inlet, a greater percentage of the precipitation falls as rain (MMS 2003).

Winds in the area are strongly influence by mountains surrounding the Cook Inlet Basin. During the months of September through April, prevailing winds are typically from the north or northwest. During May through August, winds prevail from the south. Mean speeds range from 5 knots in December to 7 knots in May (Brower et al. 1988). Site-specific, short-term data confirm the general trends described above. For example, winds measured at the West Foreland in 1999 and 2000 indicate that during September through April, prevailing winds are from the north-northeast and northeast. During June and July, winds prevail from the south-southwest and southwest. May and September are transition periods for these patterns (HCG 2000a, 2000b, 2000c, 2000d). Extreme winds are commonly out of the northeast or south (SAIC 2001).

4.2 OCEANOGRAPHY

Cook Inlet is a 350 km (217 mi) long semi-enclosed estuary that has a free connection to the open ocean (MMS 2003; MMS 2000) and a general northeast-southwest orientation. It is divided naturally into the upper and lower inlet by the East and West Forelands, where the inlet is approximately 16 kilometers (km or 10 miles) wide (SAIC 2001). Cook Inlet, and its channels, coves, flats, and marshes, are a mixture of terrestrial sources from numerous river drainages and marine waters of Shelikof Strait and the Gulf of Alaska (MMS 2003). Cook Inlet varies in width from about 100 km (62 mi) near the entrance to less than 20 km (12 mi) at its head (MMS 2000).

The lower portion of Cook Inlet is influenced by the Alaskan Stream and by a parallel current in the western Gulf of Alaska called the Kenai Current or the Alaska Coastal Current (ACC) (MMS 2003). The ACC flows along the inner shelf in the western Gulf of Alaska and enters Cook Inlet and Shelikof Strait (Schumacher and Reed 1980; Royer 1981a, 1981b). The current is narrow (less than 30 km [18.6 mi]) and high-speed (20–175 centimeters per second [cm/s] or 8 – 69 in/s) with flow that is driven by fresh water discharge and inner-shelf winds (MMS 2003). Peak velocities of 175 cm/s (69 in/s) occur in September through October (Johnson et al. 1988). The ACC transport volume ranges from 0.1-1.2 million m^3 per second (m^3/s) or 106 – 317 million gallons/s and varies seasonally in response to fresh water runoff fluctuations, regional winds, and atmospheric pressure gradients (Luick et al. 1987; Royer 1981a, 1981b, 1982; Reed et al. 1987; Schumacher and Reed 1980, 1986; Schumacher et al. 1989). Oxygen isotope measurements in late summer show that glacial meltwater may provide much of the total fresh water runoff into the ACC (Kipphut 1990).

The bottom of Cook Inlet is extremely rugged with deep pockets and shallow shoals (KPB 2007a). Upper Cook Inlet north of the Forelands is generally less than 120 ft. deep; the deepest portion is in Trading Bay, east of the mouth of the McArthur River. Two channels extend southward on either side of Kalgin Island, joining west of Cape Ninilchik. This channel gradually deepens to the south, to about 480 ft., then widening to extend across the mouth of Cook Inlet from Cape Douglas to Cape Elizabeth (KPB 2007a). The 60 ft. depth contour is generally located 2.5 to 3 miles offshore along lower Cook Inlet, but falls within 0.7 miles of shore for a length of about 3 miles near Cape Starichkof (KPB 2007a). The southeast coast of the Kenai Peninsula consists of a series of deep, glacially carved fjords (KPB 2007a). Beach substrate may be sand, hard or soft mud, gravel or cobble (Pentec Environmental 2005).

Tides in Cook Inlet are semidiurnal, with two unequal high tides and two unequal low tides per tidal day (24 hours, 50 minutes). The mean diurnal tidal range varies from 13.7 ft. at the mouth of Cook Inlet to 29 ft. in upper Cook Inlet (KPB 2007a). Strong tidal currents and inlet geometry produce considerable cross currents and turbulence within the water column. Tidal bores of up to 10 ft. have occurred in Turnagain Arm (KPB 2007a). Current velocities are influenced by local shore configuration, bottom contour and possibly wind effects in some shallow areas (MMS 2003).

Maximum surface current speeds average about 3 knots in most of Cook Inlet; however, currents may exceed 6.5 knots in the Forelands area, and have been reported at up to 12 knots in the vicinity of Kalgin Island and Drift River (KPB 2007a). The mixing of incoming and outgoing tidewater, combined with freshwater inputs, are the main forces driving surface circulation (Figure 3.12; MMS 2003).

Cook Inlet receives large quantities of glacial sediment from the Knik, Matanuska, Susitna, Kenai, Beluga, McArthur, Drift, and other rivers. This sediment is redistributed by intense tidal currents. Most of this sediment is deposited on the extensive tidal flats or is carried offshore through Shelikof Strait and eventually deposited in the Aleutian trench beyond Kodiak (KPB 2007a; MMS 2003).

Powered by the ACC, sediments of the Copper River drainage drift into lower Cook Inlet and Shelikof Strait where they eventually settle to the bottom. MMS survey results indicate that about 10-20 percent of the bottom sediments in the Cook Inlet area are from the Copper River (MMS 2000).

Sediment in Cook Inlet is generally transported along the Kenai Peninsula into lower Cook Inlet, Kachemak Bay, and Shelikof Strait (MMS 2000). Sediments transported down the west side of Cook Inlet are eventually deposited in the shallows of Kamishak Bay, while sediment is also deposited in Kachemak Bay, deeper portions of outermost Cook Inlet and Shelikof Strait (MMS 2000). Homer Spit is maintained by sediment transported from the north (KPB 2007a).

Salinity of Cook Inlet waters increases steeply and evenly along the inlet, from Point Possession to East and West Foreland. Slightly higher salinities are found on the east side. This rapid increase in salinity is due to high concentrations of glacial silt in runoff from the Matanuska, Susitna and Knik rivers and subsequent settling of sediment in upper Cook Inlet. Local areas with less salinity occur near the mouths of large glacially fed streams such as the Tuxedni, Kenai, and Kasilof rivers (KPB 2007a).

The water temperature in upper Cook Inlet varies with season from 32° to 60° F. Water temperatures of lower Cook Inlet, which are influenced by warmer, but more constant temperature waters entering from the Gulf of Alaska, range from 48° to 50°F (KPB 2007a). Higher maximum water temperatures in upper Cook Inlet may be influenced by relatively warmer water draining from lowland streams and rivers during the warmest parts of the year. Kyle and Brabets (2001) indicate that basins with 25 percent or more of their area consisting of glaciers have the coldest water temperatures during the open-water season, mid-May to mid-October. Streams and rivers that drain lowlands have the warmest water temperatures.

The ice in Cook Inlet comes from five different sources: pack ice, shorefast ice, stamukhi, estuary and river ice (Mulherin et al. 2001). Pack ice forms in seawater and is formed by the direct freezing of seawater. Shorefast ice is formed from freezing of surrounding water, from ice being piled and refrozen. Mud exposed to the air by the ebbing tide can freeze, and when seawater contacts the frozen mud, stamukhi (beach ice) forms. Stamukhi are massive ice blocks created by repeated wetting and accretion of seawater, crushing and piling of ice blocks, and stranding of successive layers of ice which freeze together. Estuary ice forms from freshwater in estuaries and rivers. River ice is much stronger than sea ice and is generally unaffected by tidal action until spring breakup (Mulherin et al. 2001).

The primary factor for ice formation in upper Cook Inlet is air temperature, and the major influences in lower Cook Inlet are the ACC temperature and inflow rate (MMS 2003). Cook Inlet ice generally begins forming in October, covers a large area by November, and melts completely in the spring (Mulherin et al. 2001). On the east side of Cook Inlet, ice may extend to Anchor Point, and on the west side, to Cape Douglas (Mulherin et al. 2001). Ice concentrations or cover are sometimes found in Kamishak Bay extending outward to Augustine Island, and Chinitna, Tuxedni and other western Cook Inlet bays (KPB 2007a).

The Cook Inlet area includes many watersheds, including 11 that drain major mountain ranges (BLM 2006). These include the Kenai Mountains on the Kenai Peninsula, the Chugach Mountains adjoining the Municipality of Anchorage, the Talkeetna Mountains in the Matanuska-Susitna area, the Alaska Range in the northwest, and the Chigmit, Neacola, and Tordillo mountains in the west (BLM 2006).

Freshwater sources include glaciers and icefields; glacial, runoff, and spring-fed streams; rivers; lakes; and wetlands. Glaciers and snowmelt provide a large portion of the input to watersheds in the Cook Inlet area (BLM 2006). In fact, glaciers cover 11 percent of the land area of the Cook Inlet basin, storing massive amounts of water as ice (Brabets and Whitman 2004).

Major rivers in the Matanuska-Susitna area include the Matanuska, Knik, Little Susitna, and Susitna rivers and their tributaries such as the Talkeetna and Yentna rivers; important lakes include Big, Nancy, Alexander, and Eklutna lakes (BLM 2006). In the Anchorage area, the primary rivers are Ship, Campbell, and Bird creeks, and Eagle and Twentymile rivers. Larger rivers on the Kenai Peninsula include the Kenai, Ninilchik, and Anchor rivers; and among the larger lakes are Tustumena, Kenai, and Skilak lakes. Important rivers on the west side of Cook Inlet include the Drift, McArthur, Theodore, McNeil, and Kamishak rivers (BLM 2006).

4.3 POTENTIAL HAZARDS

4.3.1 Volcanoes

The western shore of Cook Inlet contains seven volcanoes that have erupted in Holocene time (10,000 years ago). These are, from north to south, Hayes, Spurr, Redoubt, Iliamna, Augustine, Douglas, and Fourpeaked (about 8 miles southwest of Douglas). These volcanoes are part of the Aleutian Island Arc, a chain of volcanoes extending from south central Alaska to the far western tip of the Aleutian Islands.

The U.S. Geological Survey (USGS) monitors the 4 most active volcanoes (Spurr, Redoubt, Iliamna and Augustine). Three of these volcanoes (Spurr, Redoubt, and Iliamna) are located to the west of Cook Inlet. Augustine is an island volcano in lower Cook Inlet; it is the most active volcano in the region. All but Iliamna have erupted several times in the past 150 to 200 years and may erupt again in the future (Waythomas et al. 1997; Waythomas and Waitt 1998). Because of their composition, volcanoes in the Cook Inlet region are prone to explosive eruptions. Augustine last erupted January 11-28, 2006 and

Fourpeaked had its first historic eruption on September 17, 2007, with an ash plume to 20,000 ft (Alaska Volcano Observatory 2008). The most recent eruption of Redoubt came in March 2009 and closed the Drift River Oil Terminal after three major lahars inundated the Drift River Valley. In May 2012 interim permission was granted to Hilcorp Alaska LLC to begin using the tank farm. Ash fall associated with the 2009 eruption forced the temporary closure of the Anchorage Airport (ADN 2009).

Hazards in the immediate vicinity of the eruption include volcanic ash fallout and ballistics, lahars (mudflows) and floods, pyroclastic surges, debris avalanches, directed blasts, and volcanic gases. Lease areas in Cook Inlet would be out of the range of most of these eruption hazards except during very large eruptions (on the scale of the 1980 Mount St. Helens eruption), which tend to be rare events (Combellick et al. 1995; ADNR 2009).

During their periodic violent eruptions, the active glacier-clad stratovolcanoes produce abundant ash and voluminous mudflows that have threatened air traffic and onshore petroleum facilities (Combellick et al. 1995). These are examples of the two major categories of volcanic hazards that will continue to threaten activities in the region. Proximal hazards are those close to volcanoes and consist of a wide variety of flow phenomena on the flanks of volcanoes or in drainages which head on the volcanoes (Combellick et al. 1995). Distal hazards are those farther from volcanoes, such as ashfall and tsunamis (Combellick et al. 1995).

A proximal hazard of particular concern to the permit coverage area is flooding generated by the rapid emplacement of large volumes of hot volcanic ejecta onto snow and ice on the upper flanks of volcanoes. All the volcanoes in Cook Inlet except Augustine have permanent snow and ice stored in snowfields and glaciers on their upper flanks (Combellick et al. 1995). The largest volcanically generated flood this century was caused by the January 2, 1990, eruption of Redoubt Volcano. The flood impacted the operation of the Drift River Oil Terminal (Combellick et al. 1995). The state allowed normal loading operations to resume once a dike was installed around the tank farm and support facilities to provide protection from flooding. This work was accomplished by August 1990 and the facility returned to operation.

Another, and probably much smaller, flood came down the Chakachatna River in response to the 1953 eruption of Spurr. Floods caused by eruptions can impact any drainage on a volcano (Combellick et al. 1995). In the area of the lease sale, drainages that could be impacted by volcanigenic floods are the Chakachatna River drainage (from Trading Bay to the McArthur River), Drift River drainage (from Montana Bill Creek to Little Jack Slough), Redoubt Creek, and the Crescent River. This is approximately half of the lease sale lands on the western shore of Cook Inlet. Drift River and Chakachatna River are the most likely to host floods. A very large debris avalanche came down Redoubt Creek and formed the land that now underlies Harriet Point in latest Pleistocene time (1 million years ago), but that drainage does not appear to have had a large flow since that time (Combellick et al. 1995, citing to Beget and Nye 1994). Large flows, some of which reached the present shoreline, came down Crescent River between about 3,600 and 1,800 years ago (Combellick et al. 1995). The most probable volcanically induced floods are small, water-rich floods, which depending on the local hydrographic conditions, could impact roads, pipelines, and other infrastructure (Combellick et al. 1995).

Other proximal volcanic hazards on the western shore of Cook Inlet are lava flows, block-and-ash flows, pyroclastic flows, and hot gas surges. The lands included in the lease area are far enough from the volcanoes that they are out of range of all but the very largest eruptions (eruptions on the scale of the 1980 Mount St. Helens or 1991 Mt. Pinatubo eruption). Eruptions this large are rare, although they are certainly possible and have happened at several of the Cook Inlet volcanoes, the most recent being the eruption of Mt. Katmai in 1912.

The most common distal hazard is ashfall, where volcanic ash (finely ground volcanic rock) is lofted into the atmosphere and stratosphere by explosive eruptions, drifts downwind, and falls to the ground. There have been dozens of such events from Cook Inlet volcanoes since 1900. In most cases, volcano ashfalls have been a few millimeters or less in thickness. The primary hazard of such ashfalls is damage to mechanical and electronic equipment such as engines, which ingest ash past the air filter, computers, and transformers, possibly causing electrical shorts. Ashfalls of a few millimeters should be expected throughout the Cook Inlet and Susitna basins with a long-term average frequency of a few every decade or two. Ashfalls thick enough to collapse buildings are possible but rare (Combellick et al. 1995).

4.3.2 Tsunamis and Seiches

A tsunami is a series of long ocean waves generated by the displacement of a large volume of water caused by earthquakes, volcanic eruptions, submarine landslides, or onshore landslides that rapidly release large volumes of debris into the water. Most tsunami waves affecting south central Alaska are generated along subduction zones bordering the Pacific Ocean where motion along a dip-slip fault and the elastic rebound of subducting crust, produced by an earthquake of magnitude greater than 6.5 on the Richter scale, causes vertical displacement of the seafloor. The great seismicity associated with the subduction zone of the Aleutian-Alaskan megathrust fault system makes the southern coastal region of Alaska, especially the Gulf of Alaska and the Aleutian Islands, highly susceptible to tsunamis (Costello 1985).

Tsunamis are typically not hazardous to vessels and floating structures on the open ocean because of their small wave heights (less than a few feet). However, they are potentially very damaging to coastal regions and nearshore facilities because wave heights can increase significantly as tsunamis approach shallow water. High, breaking waves that reach the shoreline at high tide cause much more damage than waves that are low and nonbreaking or that occur at low tide (Combellick and Long 1983; MMS 1992).

Because of the shallow, elongated configuration of Cook Inlet and its narrow entrances, the hazard from distant tsunamis is low. The hazard from local tsunamis is also low because there are no active surface faults in the inlet, no adjacent steep slopes to serve as sources of massive slides into the inlet, and no evidence of thick, unstable seafloor deposits that could fail and create massive underwater slides. Local landslide-generated tsunamis, however, can be quite large and potentially damaging, as demonstrated by the series of 4.6 to 9.1 m (15 to 30 ft) waves that reportedly hit Nanwalek and Port Graham on the east side of lower Cook Inlet as a result of a debris avalanche caused by the eruption of Augustine Volcano in 1883 (Waythomas and Waitt 1998; Kenai Peninsula Borough 2011). Future eruptions of Augustine could potentially generate a tsunami in lower Cook Inlet if significant volumes of volcanic debris were to enter the sea rapidly (although this remains a topic of debate). Modeling studies indicate that a moderate wave is possible (with lead times of about 27 to 125 min), but the likelihood of a tsunami is considered to be low. None of the last five eruptions of Augustine Volcano, including the latest one in 2006, resulted in a tsunami; nevertheless, the West Coast and Alaska Tsunami Warning Center and the Alaska Volcano Observatory continue to refine their public outreach strategy to deal with a volcanogenic tsunami because local consequences of such an event could be high (Neal et al. 2011; Waythomas and Waitt 1998; ADNR 2009a).

Seiches are periodic oscillations of standing waves in partially or completely enclosed water-filled basins like lakes, bays, or rivers triggered by changes in wind stress or atmospheric pressure and, less commonly, by landslides and earthquakes (McCulloch 1966). In Alaska, they may also be generated by the collapse of deltas into deep glacial lakes (Kenai Peninsula Borough 2011). An example is the Lituya Bay earthquake of 1958 (Moment Magnitude (Mw) 8.2), which caused a landslide at the head of Lituya Bay (on the Gulf of Alaska) and generated a seiche with a wave run-up of about 530 m (1,750 ft) (MMS 1992; Bouma and Hampton 1986).

During the Great Alaska Earthquake of 1964 (Mw 9.2), tsunamis were generated by uplift of the seafloor and seiches were generated by landslides in semiconfined bays and inlets (USGS 2011b; MMS 1992). Because the Kenai Peninsula is susceptible to earthquakes with magnitudes greater than M 6.0, the Kenai Peninsula Borough mitigation plan rates the coastal communities and facilities in lower Cook Inlet (south of the Forelands) as highly vulnerable to tsunamis — vulnerable communities include Port Graham, Nanwalek, Seldovia, Homer, Anchor Point, and Ninilchik. The tsunami risk for upper Cook Inlet, however, is considered low because of its relatively shallow depth and its distance from the lower end of the inlet (Kenai Peninsula Borough 2011).

4.3.3 Marine and Seafloor Hazards

Cook Inlet has a maximum tidal range of 4 to 11 m (13 – 36 ft), depending on location, which produces rapid tidal flows and strong riptides (Combellick et al. 1995, citing to Evans et al 1972, Hayes et al. 1976, National Oceanic and Atmospheric Administration 1977). High tidal-current velocities in upper Cook Inlet prevent deposition of clay and silt-size sediments, which largely remain in suspension. Bottom sediments in the permit coverage area are mainly gravel and sandy gravel with gravel content of 50-100 percent (Combellick et al. 1995, citing to Sharma and Burrell 1970). Similar deposits in lower Cook Inlet are thought to be reworked and redistributed coarse-grained glacial material (Combellick et al. 1995, citing to Rappeport 1981). These deposits show no evidence of gravitationally unstable slopes or soft, unconsolidated sediment (Combellick et al. 1995, citing to MMS 1995).

Several pipeline failures in upper Cook Inlet have been directly attributed to the current-sediment interaction. As the bottom sediments shift under the influence of bottom currents, sections of the pipeline are undermined and become unsupported. The pipeline may then flutter, which causes fatigue and failure.

4.3.4 Ice Hazards

During the winter months, ice forms up to 1 m (3 ft) thick on upper Cook Inlet. This ice, propelled by the swift tidal currents, creates very large load stresses on the offshore platforms. Since the platforms are designed to withstand the ice loads, this should not present a problem. Ice is not as severe a problem in the southern part of the inlet due to a higher salinity, less fresh water inflow, and a greater proportion of warm ocean waters.

Winter ice conditions combined with tidal action may occasionally hinder offshore operations in the upper inlet from December through April (Combellick et al. 1995, citing to Sharma and Burrell 1970). During the winter of 1970-1971, inlet ice extended as far south as Anchor Point and Cape Douglas. Although blocks of floe ice generally reach a thickness of 1.2 m (3.9 ft) in Cook Inlet, grounding of these blocks forms large piles (stamukhi) that exceed 12 m (39 ft) in thickness and, where floated, stamukhi have damaged ships in the inlet (Combellick et al. 1995, citing to Evans et al. 1972). Numerous large erratic blocks in shallow, nearshore waters are hazards to ship navigation.

Three forms of ice normally occur in Cook Inlet: sea ice, beach ice, and river ice. Sea ice is the predominant type and is formed by freezing of the inlet water from the surface downward. Because of the strong tidal currents, ice does not occur as a continuous sheet but as ice pans. Pans can form up to 1 m (3 ft) thick and be 305 m (1,000 ft) or greater across (SAIC 2001). They can also form pressure ridges reportedly up to 5.5 m (18 ft) high (Gatto 1976). Sea ice generally forms in October or November, gradually increasing from October to February from the West Foreland to Cape Douglas, and melts in March to April (Brower el al. 1988). The primary factor for sea ice formation in upper Cook Inlet is air temperature, and for lower Cook Inlet it is the ACC temperature and inflow rate (Poole and Hufford 1982).

Beach ice, or stamukhi, forms on tidal flats as sea water contacts cold tidal muds. The thickness of beach ice is limited only by the range of the tides and has been noted to reach 9 m (30 ft) in thickness. During cold periods, beach ice normally remains on the beach; however, during warm weather in combination with high tides, it can melt free and enter the inlet. Blocks of beach ice that enter the inlet are normally relatively small (less than several tens of feet across) and have relatively low strengths (SAIC 2001).

River ice can also occur in Cook Inlet. It is a fresh water ice that is similar to sea ice except that it is relatively harder. It is often discharged into the inlet during spring breakup (SAIC 2001).

4.3.5 Flood Hazards

In addition to volcanigenic flooding on the west side of Cook Inlet, flood hazards in the Cook Inlet area may result from glacial outburst (jökulhlaups), ice jams, and high rainfall. Glacial outburst occurs when glacial movement opens a pathway for water trapped behind a glacier to escape. Rivers are subject to large magnitude outburst floods as a result of the sudden drainage of large, glacier-dammed lakes, particularly on the west side of Cook Inlet. Major rivers affected by outburst floods include Beluga, Chakachatna, Middle, McArthur, Big, and Drift rivers (Combellick et al. 1995, citing to Post and Mayo 1971). For example, in September 1982, over 95 percent of Strandline Lake drained, releasing about 700 million m^3 (185 billion gallons) of water. Strandline Lake has drained catastrophically into the Beluga

River every 1 to 5 years since about 1954 (Combellick et al. 1995, citing to Sturm and Benson 1988). The most reliable predictor of outburst floods from Strandline Lake is the development of a calving embayment in the lobe of Triumvirate Glacier, which dams the lake (Combellick et al. 1995).

Ice jam flooding occurs during the spring breakup process when strong ice or constrictions in a river (bends or obstructions like islands or gravel bars) create jam points that cause moving ice along the breakup front to stop (NOAA 2011). It also occurs when low density ice masses (frazil ice) become trapped and pile up under surface ice. The ice stoppage causes water levels to rise and flood the adjacent land. Ice jams are more often associated with single-channel rivers in interior and northern Alaska than in rivers of the Cook Inlet drainage basin, but a flood from an ice jam downstream of Skilak Lake in the Kenai River watershed (east of Cook Inlet) occurred in 1969 after an outburst from Skilak Glacier at the head of Skilak Lake, creating a record high river stage (74.25 m [22.63 ft]) and causing severe damage in Soldotna.

Ice jams are unpredictable and have the potential to be worse than 100- or 500-year events, causing heavy damage to bridges, piers, levees, jetties, and other structures along the riverbank (Brabets et al. 1999; NOAA 2011; ADNR 2009; Kenai Peninsula Borough 2011).

In January and February 2007, an ice jam flood occurred on the Kenai River, triggered by the release of the Skilak Glacier dammed lake (Kenai River Center 2007). The Kenai River at Skilak Lake rose about 3.8 ft, causing the ice cover to break up and form ice jams and localized flooding in the Soldotna area. The rapid increases in water level and moving ice caused significant property damage.

Signs of impending outburst releases are high lake water levels, abundant calving into the lake, and water present on northern margins of the glacier, including small marginal lakes (Combellick et al. 1995, citing to unpublished data, National Weather Service, October 1995). The flooding in the Cook Inlet area may also be caused by heavy rainfall. For example, heavy flooding of the Kenai River in September 1995 resulted from interaction of tropical moisture and a deep low pressure center in the north Pacific Ocean; blockage of the eastward movement of this low by a high-pressure ridge in eastern Alaska and western Canada; saturated soil conditions; and greater than normal glacial melt due to preceding storms. Excess sediment deposition in channels due to rapid runoff decreased the carrying capacity of the streams. As a result, the lower Kenai River remained above flood stage for over 10 days. Crest water levels were 1.1 m (3.6 ft) above flood stage at Kenai Keys and 0.76 m (2.5 ft) above flood stage at Soldotna (Combellick et al. 1995, citing to unpublished data, National Weather Service, October 1995). An analysis of this flood indicates that it represents a 100-year event at Soldotna (USGS 1998).

In August 2006, days of heavy rain caused major flooding of the Little Susitna River, Willow Creek, Montana Creek, the Talkeetna River, and Moose Creek in the Matanuska-Susitna Borough. These rivers crested well above the flood stage, resulting in the evacuation of about 150 people, 46 borough roads and 6 major state roads flooded or damaged, 8 bridges damaged, closures and damage to the Parks Highway and Alaska Railroad, and over 150 homes flooded or damaged (MSB 2006).

The primary hazards to facilities from river flooding are high water levels, bank erosion, deposition at the river mouth, high bedload transport, and channel modification (Combellick et al. 1995). Seasonal flooding of lowlands and river channels is extensive along major rivers that drain into Cook Inlet. Thus, measures must be taken prior to facility construction and field development to prevent losses and environmental damage. Pre-development planning should include hydrologic and hydraulic surveys of spring break-up activity as well as flood frequency analyses. Data should be collected on water levels, ice floe direction and thickness, discharge volume and velocity, and suspended and bedload sediment measurements for analysis. Also, historical flooding observations should be incorporated into a geologic hazard risk assessment. All inactive channels of a river must be analyzed for their potential for reflooding. Containment dikes and berms may be necessary to reduce the risk of flood waters that may undermine facility integrity.

5.0 DESCRIPTION OF THE EXISTING BIOLOGICAL ENVIRONMENT

This section provides an overview of the biological communities found within Cook Inlet. The general groups of aquatic organisms that inhabit the Cook Inlet include pelagic (living in the water column), epontic (living on the underside or within the sea ice), or benthic (living on or within the bottom sediments) plants and animals. The categories of offshore biological environment that will be discussed include:

- Plankton
- Attached macro- and microalgae
- Benthic invertebrates
- Fishes (demersal and pelagic)
- Marine mammals
- Coastal and marine birds
- Threatened and endangered species
- Essential fish habitat.

Each of these biological resources is assessed in terms of seasonal distribution and abundance, growth and production, environmental factors, and habitats.

5.1 PLANKTON

Plankton can be divided into two major classes: phytoplankton and zooplankton. Plankton are the primary food base for other groups of marine organisms found within the Cook Inlet. The distribution, abundance, and seasonal variation of these organisms are strongly influenced by the physical environment.

5.1.1 Phytoplankton

5.1.1.1 Distribution and Abundance

During summer months, lower Cook Inlet is among the most productive high-latitude shelf areas in the world (MMS 1996). The distribution and abundance of phytoplankton in northern Cook Inlet is limited by extreme tidal variation and severe turbidity. The silt-laden waters that enter Upper Cook Inlet load the inlet with sediment retard phytoplankton growth (e.g. primary productivity) by reducing light penetration (Kinney et al. 1970).

During a limited study in the Cook Inlet area Piatt (2002) determined that phytoplankton biomass varied among years and areas; however, a consistent finding was the lack of phytoplankton biomass in the western half of lower Cook Inlet. The same study found that standing stocks of phytoplankton were highest in stratified waters of outer Kachemak Bay in most years, although high production was observed in mixed waters off Kachemak Bay for one year of the study period (1998). The authors note that these findings were consistent with previous work by Larrance and Chester (1979) and lack of primary productivity was likely due to high sediment loads in the water that prevent light from penetrating surface layers.

Highlighting the relationship of the physical environment on phytoplankton distribution and abundance, Eslinger et al. (2001) described two types of spring phytoplankton blooms in the nearby Prince William Sound that appear to correspond with stratification. The first type of bloom appears during springs in which early, strong physical stratification developed. Eslinger et al. (2001) described this type of phytoplankton bloom to be intense and short-lived. The second type of bloom appears during springs in which slower, weaker stratification developed. This bloom was described as prolonged and requiring more time to peak when compared to the first type. Eslinger et al. (2001) concluded that the slower blooms led to prolonged periods of phytoplankton production, prolonged interaction with the springtime grazing of copepods and other zooplankton, and the incorporation of more organic matter into pelagic food webs. The typical conditions in Cook Inlet, which has strong tidal mixing, are probably similar to the prolonged spring blooms in Prince William Sound.

5.1.1.2 Growth and Production

The annual primary production in Cook Inlet is estimated in the range of 100-300 grams carbon per meter squared per year (USDOI, MMS, Alaska OCS Region, 1995:III.B-1). Primary productivity in lower Cook Inlet peaks in the spring (April-May) but remains high in outer Kachemak Bay throughout summer (Larrance and Chester 1979). Primary productivity remains high due to upwelling in Lower Cook Inlet; thus, a continuous supply of nutrient fueling the primary productivity (Winant and Olson 1976, Larrance et al. 1977).

The growth rates of planktonic organisms are relatively rapid, and the generation lengths are relatively short. Computer modeling by Willette et al., (2001) suggests that phytoplankton populations replace themselves (i.e., the total biomass doubling or turnover time) in about 4 days. Further, the lag between a phytoplankton bloom and the retreating edge of the sea ice usually is only 2 to 3 weeks (Wang et al. 2004 cited in MMS 2007) indicating rapid reproductive response by the phytoplankton community once conditions for growth are available.

5.1.1.3 Environmental Factors

Phytoplankton production is usually limited to the *photic zone*, or the depth to which sunlight penetrates the water. The major environmental factors influencing phytoplankton production are temperature, light and nutrient availability. Additional environmental factors may influence phytoplankton production on smaller scales within the Cook Inlet itself.

Environmental conditions on the east side of Cook Inlet especially south of Deep Creek or Ninilchik, are substantially less rigorous than those observed on the west side of the inlet. These environmental factors include high turbidity, greater deposition rates, lower water and air temperatures, lower salinity, and larger quantities of ice and greater ice scour. The biological consequences of these conditions are a thinner euphotic zone, resulting in far less primary productivity, especially for phytoplankton.

Carmack et al. (2004) suggest that while light limitation due to snow and ice cover may control the timing of primary production along the Canadian Shelf of the Beaufort Sea, the availability of nutrients ultimately sets the annual production limits. Carmack et al. (2004) report that phosphorus limits production over the inner shelf [depth < 20 m (< 65.6 ft)], whereas nitrogen limits production over the middle [20 to 80 m (65.6 to 262.5 ft)] and outer [shelf-break; > 80 m (>262.5 ft)] shelf. Seasonal variation in nutrient concentration may also affect primary production. In spring, maximum primary production occurred near the surface and decreased exponentially with depth. In summer, as nutrients became depleted in the upper mixed layer, a deep chlorophyll maximum, indicative of a high abundance of phytoplankton, developed toward the bottom of the winter mixed layer [20 to 40 m (65.6 to 131.2 ft)] (MMS 1991; Carmack et al., 2004). Although not located in the Cook Inlet, this study provides relevant information on phytoplankton production, and is likely similar to conditions and processes occurring within the Cook Inlet.

5.1.1.4 Phytoplankton Habitat

Phytoplankton production is limited primarily by temperature, available nutrients (particularly nitrogen), and light. The most productive area of Alaskan waters is the coastal zone. Primary productivity within the coastal zone was highest in the water column where diatoms were the most abundant organism. Phytoplankton production gradually increases after ice break-up, when light becomes available. A review of the available literature by Piatt (2002) indicates that the key to the initiation of phytoplankton blooms in the Cook Inlet is stratification of the water column. In addition, water transparency must be adequate to permit 1% of the light incident to the surface to penetrate deeper than about 10 m (32.8 ft) (Larrance et al. 1977). Production declines after September when light availability limits photosynthesis.

5.1.2 Zooplankton

Zooplankton are consumed by fish, shellfish, marine birds, and some marine mammals; thus supporting higher trophic levels in the Arctic and sub-Arctic food-webs. Zooplankton feed on phytoplankton, and their growth cycles respond to phytoplankton production. In the lower Cook Inlet, zooplankton populations vary seasonally with biomass reaching a low in the early spring and a peak in late spring and summer. Zooplankton are most abundant in the lower Cook Inlet when compared to the upper Cook Inlet (SAIC 2002).

5.1.2.1 Distribution and Abundance

There is a diverse zooplankton community in lower Cook Inlet. Sampling of zooplankton abundance in Shelikof Strait and surrounding shelf waters from March to October 1985 and then in Shelikof Strait during spring 1986 – 1989 determined that the zooplankton fauna was a mixture of oceanic and continental shelf taxa and strongly influenced by abundance of *Neocalanus plumchrus* and *Metridia pacifica*. Biomass of copepods showed some large interannual differences related to abundance of oceanic taxa (Incze et al. 1996). Dominant copepods may include the calanoid copepods *Pseudocalanus minutus* and *P. newmani.*

Some of the highest standing stocks of zooplankton in the Gulf of Alaska are found in Cook Inlet during spring and summer, following the spring phytoplankton bloom. Peak densities in excess of 1000 mg/m^3 are not unusual. Studies by Piatt (1994) found that zooplankton were most abundant (ea. 60-80 mg/m^3) on the northeast side of the entrance to Cook Inlet. Analyses conducted by Piatt (1994) determined that no significant variation in total zooplankton biomass across the entrance to the Cook Inlet existed between areas of low, or high sea surface salinity. In some cases, when examined on a taxa level, it was determined that zooplankton varied significantly with location or salinity. For example, *Acartia longiremis* was common at all stations, but generally more abundant in the southwestern portion of the lower Cook Inlet. Similarly, *Centropages* spp., *Cladocera* spp., Euphausiid furcilia, and Appendicularia were all more abundant at southwestern stations and in higher salinity water (Piatt 1994).

5.1.2.2 Growth and Production

The growth rates of zooplankton are relatively rapid, and the generation lengths are relatively short. For example, the body weight doubled every 2 weeks among immature stages of the common mysid, *Mysis litoralis*, during summer 1977 to 1978 field studies in Simpson Lagoon, and the generation length was 1 to 2 years (MMS 2003). The rapid growth rates also were evident during formation of typical summer "blooms" during 1977 and 1978. Although this study was completed in the Beaufort Sea, growth rates are likely similar for *Mysis* spp. in the Cook Inlet.

Computer modeling by Willette et al. (2001) suggests that the zooplankton populations replace themselves in about 16 days, based on the maximum mortality rate of zooplankton. These estimates are similar to the standard turnover times in textbooks for temperate, eutrophic coastal waters (Lalli and Parsons 1997).

5.1.2.3 Environmental Factors

While zooplankton are heterotrophic, many are major consumers of phytoplankton. Thus, many of the factors influencing phytoplankton primary productivity indirectly affect zooplankton populations. Through their consumption and processing of the phytoplankton, zooplankton species act as an important link in aquatic food webs by transporting organic material from primary production sources to larger, carnivorous predators, including species of whales that feed on pelagic zooplankton.

5.1.2.4 Zooplankton Habitat

Zooplankton standing stock generally fluctuates in response to phytoplankton production; thus, persistently high levels of phytoplankton production support a larger standing stock of zooplankton in lower Cook Inlet during spring and summer (Cooney 1986). Zooplankton, like phytoplankton, make excellent indicators of environmental conditions since population densities are sensitive to changes in water quality and environmental conditions. Population densities will decrease in response to low dissolved oxygen, low nutrient levels, high levels of toxic contaminants, poor food quality, and/or increase in and predation.

5.1.3 Attached Macroalgae and Microalgae

5.1.3.1 Macroalgae

Attached macroalgae (primarily kelp, *Laminaria* spp*.,* and macroscopic red and green algae) occur in state waters along nearshore areas containing suitable rocky substrate for attachment. The rocky intertidal and shallow subtidal floral communities in southwestern lower Cook Inlet are dominated by the brown algae *Fucus,* and kelp *(*mainly bull kelp, *Nereocystis luetkean)* and ephemeral red algae (mainly *Rhodymenia* spp.) (USDOI, MMS, Alaska OCS Region, 1995: Section III.B.1.b).

5.1.3.1.1 Distribution and Abundance

Sheath et al. (1996) sampled stream segments in the Cook Inlet drainage basin for algae abundance. This study found 40 species of lotic macroalgae with the major divisions in terms of species number being Chlorophyta (43%), Bacillariophyta (25%), Rhodophyta (13%) and Xanthophyta (13%). Filaments were the predominant form (60% of species). Distribution was determined to be patchy in the basin, with total cover varying from less than 1% to 90% of the stream bottom. Sheath et al. (1996) determined that lowland brown-water streams flowing through emergent wetlands tended to have the highest species diversity and abundance.

In arctic and sub-Arctic Alaskan waters the distribution of kelp is limited by three main factors: ice gouging, sunlight, and hard substrate. Ice gouging restricts the growth of kelp to protected areas, such as behind barrier islands and shoals. Sunlight restricts the growth of kelp to the depth range where a sufficient amount penetrates to the seafloor, or water less than about 11 m (36 ft) deep. Hard substrates, which are necessary for kelp holdfasts, restrict kelp to areas with low sedimentation rates. Macroalgae are unlikely to occur in shallow water areas lacking a rocky substrate. However, benthic algae have been noted in areas where rock substrates were lacking, but these algal beds did not contain the diverse epilithic fauna that characterized areas with suitable rocky substrate (Dunton et al. 1982; MMS 1990).

Within outer Kachemak Bay, Foster (2010) described kelp beds with both dense canopy and understory layers extending to depths of 18 m (60 ft or more) were widespread. North of Kachemak Bay as far as Anchor Point, on the east side of Cook Inlet, the moderately developed kelp beds extended to shallower depths and displayed a thinner canopy, and a more moderate understory. In contrast, in Kamishak Bay, on the west side of Cook Inlet, kelps beds, limited to understory kelps, were rare to absent and restricted to lower intertidal depths.

5.1.3.1.2 Growth and Production

Kelp in arctic and sub-arctic water grows fastest in late winter and early spring due to higher concentrations of inorganic nitrogen in the water column (ADNR 2009). Sediments trapped in the ice above the kelp block light and restrict growth while the presence of leads and cracks has the opposite effect (ADNR 2009). Bull kelp is the predominant kelp species in the Cook Inlet area, and is also one of the largest fastest-growing marine algae, attaining lengths of 40 m (131 ft) during the growing season

(Schoch 2001). In Kachemak Bay, located outside the Cook Inlet, a total of 30.6 km^2 (11.8 mi^2) of kelp canopy was measured; an additional 17 km^2 (6.6 mi^2) were measured from Anchor Point to Point Pogibshi (Schoch 2001).

5.1.3.1.3 Environmental Factors

Kelp support a large invertebrate community. Physical, chemical and biological factors affect dynamics of kelp beds and their annual fluctuations. These include water motion, temperature, salinity, nutrients, light intensity, available habitat, and invertebrate predation (Schoch 2001).

5.1.3.1.4 Macroalgae Habitat

Macroalgae show a distinct and fixed pattern of vertical distribution in their habitat. Some of these plants inhabit the coast above high water mark, whereas others populate the intertidal zone or the sublittoral zone. Macroalgae populations occur naturally, but an increase in their biomass (especially if it is associated with a decrease in seagrass) may also be an indication of deteriorating water quality. Macroalgal biomass is most commonly limited by dissolved inorganic nitrogen, but can also be limited if high light attenuation prevents adequate light reaching the bottom.

Hard substrates, which are necessary for kelp holdfasts, restrict kelp to areas with low sedimentation rates. Macroalgae are unlikely to occur in shallow water areas lacking a rocky substrate. However, benthic algae have been noted in areas where rock substrates were lacking, but these algal beds did not contain the diverse epilithic fauna that characterized areas with suitable rocky substrate (Dunton et al. 1982; MMS 1990).

5.1.3.2 Microalgae

While the mechanism of photosynthesis in microalgae is similar to that of higher plants, they are generally more efficient converters of solar energy because of their simple cellular structure. In addition, because the cells grow in aqueous suspension, they have more efficient access to water, CO_2, and other nutrients.

5.1.3.2.1 Distribution and Abundance

Spring and summer Cook Inlet populations of microalgae are dominated by diatoms and microflagellates, with chrysophytes and dinoflagellates (Larrance et al. 1977).

In general, attached microalgae are most likely to occur in areas not subjected to ice gouging and land fast ice, and where hard substrates suitable for attachment occur (MMS, 1990). However, benthic algae have been noted in areas where rock substrates were lacking, but these algal beds did not contain the diverse epilithic fauna that characterized areas with suitable rocky substrate (Dunton et al., 1982).

Benthic microalgae occur in sediments and within the macroalgal communities. Benthic microalgae may be a significant source of primary productivity in nearshore areas, but in areas of kelp production, the contribution of benthic microalgae may be relatively small.

5.1.3.2.2 Growth and Production

Light appears to be the limiting factor which controls the distribution, development, and production of the ice-algal assemblage (MMS 1990). The ice-algal bloom usually occurs in April and May and occasionally in early June, while the open water phytoplankton bloom does not occur until ice breakup is underway.

5.1.3.2.3 Environmental Factors

These algae are the primary food source for a variety of animals, including amphipods, copepods, ciliates, various worms, and juvenile and adult fishes (MMS 1991)

5.1.3.2.4 Microalgae Habitat

Benthic microalgae occur in sediments and within the macroalgal communities. Benthic microalgae may be a significant source of primary productivity in nearshore areas, but in areas of kelp production, the contribution of benthic microalgae may be relatively small.

5.1.4 Benthic Invertebrates

Benthic invertebrates are organisms that live on the bottom of a water body (or in the sediment) and have no backbone. The size of benthic invertebrates ranges from microscopic (e.g., microinvertebrates, <10 microns) to a few tens of centimeters or more in length (e.g., macroinvertebrates >50 cm [19.7 in]). Benthic invertebrates live either on the surface of bedforms (e.g., rock, coral or sediment - epibenthos) or within sedimentary deposits (infauna), and comprise several types of feeding groups (e.g., deposit-feeders, filter-feeders, grazers and predators).

Foster (2010) determined dominant benthic tax on the west side of Cook Inlet and the east side of lower Cook Inlet and Prince William Sound. Foster (2010) indicated that the dominant benthic taxa on the west side of Cook Inlet, in decreasing order of abundance, were prosobranch gastropods, bivalves, ascophoran and anascan bryozoans, and decapod crustaceans. In Kachemak Bay on the east side of lower Cook Inlet and in Prince William Sound, the prosobranch gastropods strongly dominated the fauna, followed by bivalves. Decapod crustaceans were also well represented in both regions.

5.1.4.1 Distribution and Abundance

The distribution, abundance, and seasonal variation of benthic species in Arctic and sub-Arctic Alaska waters are strongly correlated with physical factors (e.g., substrate composition, water temperature, depth, dissolved oxygen concentrations, pH, salinity, sediment carbon/nitrogen ratios, and hydrography). Larger invertebrate communities are found in nearshore lagoons. These communities include animals living in the bottom (infauna), animals living on or near the bottom (epibenthic), and those which live in the water column (pelagic). During winter, epibenthic and pelagic species disappear, and then emerge again in spring, whereas infauna and some amphipods may be present year-round (ADNR 2009).

In nearshore waters with depths less than 2 m (6.6 ft), relatively few species are found because the ice in this region extends all the way to the seafloor during winter. Therefore, the abundance of most species is probably dependent on annual (or more frequent) colonization. Biomass and diversity in the inshore zone generally increase with depth, except in the shear zone between approximately 15 to 25 m (49 to 82 ft). Intensive ice gouging occurs in this zone, which disturbs the sediments and presumably limits the abundance of infaunal species (Braun, 1985). Ice gouging continues out to about 40 m (131 ft) with decreasing intensity. Diversity and biomass of infauna increase beyond this zone with distance offshore, at least as far as the continental shelf boundary [200 m (656 ft)] (MMS 1990).

Mollusks, polychaetes, and bryozoans dominate the infauna of seafloor habitats in Cook Inlet. Feder (1981) found over 370 invertebrate taxa in samples from lower Cook Inlet. Substrates consisting of shell debris generally have the most diverse communities and are dominated by mollusks and bryozoans (Feder and Jewett 1987). Muddy-bottom substrates are occupied by mollusks and polychaetes, while sandy-bottom substrates are dominated by mollusks. Nearshore infauna, where sediments are fine and sedimentation rates are high, consists mostly of mobile deposit-feeding organisms that are widely distributed through the area. Infaunal organisms are important trophic links for crabs, flatfishes, and other organisms common in the waters of Cook Inlet (SAIC 2002).

Epifauna are dominated by crustaceans, mollusks, and echinoderms (SAIC 2002). The percentage of sessile organisms in Cook Inlet is relatively low inshore and increases towards the continental shelf (Hood and Zimmerman 1986). Rocky-bottom areas consist of lush kelp beds with low epifaunal diversity; moderate kelp beds with well-developed sedentary and predator/scavenger invertebrates; and little or no kelp with moderately developed predator/scavenger communities and a well-developed sedentary invertebrate community (Feder and Jewett 1987).

5.1.4.2 Growth and Production

Available nutrition decreases as the distance from shore increases resulting in decreased benthic productivity. Sediment grain size influence benthic species composition, suspension feeding species on coarser sediments while deposit feeding species prefer fine sediment. Nearshore habitats widely range in temperature and salinity. Many benthic organisms survive these fluctuations by digging into sediment or moving to a different area. In lagoon areas water currents help move invertebrates towards shore to recolonize shallow areas after bottom fast ice moves out, exposing the onshore sediments (Griffiths and Dillinger 1980).

5.1.4.3 Environmental Factors

The abundance, diversity, biomass, and species composition of benthic invertebrates can be used as indicators of changing environmental conditions. The biomass of benthic invertebrates declines if communities are affected by prolonged periods of poor water quality especially when anoxia and hypoxia are common. Benthic communities can change in response to:

- nutrient enrichment leading to eutrophication;

- bioaccumulation of toxins to lethal levels in molluscs (shellfish), crustaceans, polychaetes and echinoderms, causing the loss of herbivorous and predatory species;
- lethal and sub-lethal effects of heavy metals and other toxicants derived from oil and gas activities;
- dislodged epifauna and infauna from trawling and dredging which may result in the collection and mortality of a substantial invertebrate bycatch;
- the replacement of the existing benthic community with other benthic species due to physiological stress and/or by competition or predation by species better physiologically suited to the modified conditions; and
- changes in the physical and biological characteristics and structure of habitats (i.e., their function), including supporting habitat such as seagrass meadows and sandy soft bottom areas.

Burrowing and tube-building by deposit-feeding benthic invertebrates (bioturbators) helps to mix the sediment and enhances decomposition of organic matter. Nitrification and denitrification are also enhanced because a range of oxygenated and anoxic micro-habitats are created. Loss of nitrification and denitrification (and increased ammonium efflux from sediment) in coastal systems is an important cause of hysteresis, which can cause a shift from clear water to a turbid state. The loss of benthic suspension-feeding macroinvertebrates can further enhance turbidity levels because these organisms filter suspended particles including planktonic algae, and they enhance sedimentation rates through biodeposition (i.e., voiding of their wastes and unwanted food).

The western side of Cook Inlet is "influenced by freshwater runoff and a high concentration of river-derived sediments carried from the upper inlet" (Feder and Jewett 1987). Feder and Jewett (1987) suggest that the turbid waters restrict primary productivity especially in the early spring . This pattern of currents and turbidity appears to present a very effective barrier to transport and/or survival of planktonic larvae of marine invertebrates from the east side of the inlet to the west side but possibly, some types of larvae (e.g., razor clams) are able to move successfully across the inlet.

5.1.4.4 Benthic Invertebrates Habitat

In addition to high turbidity, Cook Inlet is characterized by extreme tidal fluctuations of up to 12.2 m (40 ft) (NOAA 1999) that produce strong currents in excess of 8 knots (Tarbox and Thorne 1996). The amount of protected benthic habitat is likely reduced by the periodic scouring or substrate movement caused by Cook Inlet currents that bottleneck at the Forelands, near the Osprey Platform (SAIC 2002).

5.2 FISHES

Few studies of marine fish in upper Cook Inlet have been published. The fish of central and lower Cook Inlet have been better studied, due in part to the numerous commercial fisheries in the area. Because of low phytoplankton productivity and the severe tidal currents, it is thought that upper Cook Inlet does not provide a plentiful primary food source or much safe habitat for fish (SAIC 2002). However, recent studies of beluga utilization of Cook Inlet may warrant further investigation of Cook Inlet forage fish (NMFS 2000a).

5.2.1 Distribution and Abundance

The fishes occurring in the Arctic and sub-Arctic Alaska waters fall into three basic categories (MMS 2003):

1) freshwater species that may occasionally enter marine waters,
2) anadromous species that spawn in freshwater and migrate seaward as juveniles and adults, and
3) marine species that complete their entire life cycle in the marine environment.

Freshwater, anadromous and marine fish species can also be described by two categories: pelagic and ground fishes. At least 52 species of nearshore fish have been described in Cook Inlet. Of those species, 50 species were reported in Kachemak Bay, 24 species at Chisik Island, and 12 species at Barren Island sampling locations (Piatt et al 1999). The abundance and species composition of pelagic fish in Cook Inlet increased by about an order of magnitude and diversity decreased when sampled from North (Chisik) to South (Barrens) (Piatt and Roseneau 1997). Trawls to sample ground fish found similar results (Piatt and Roseneau 1997). Common pelagic and ground fishes in Cook Inlet are discussed below with reference to distribution and abundance in Cook Inlet.

5.2.2 Pelagic fish

Pelagic fishes usually inhabit the water layers above the abyssal zone (water below 4,000 m) and beyond the littoral zone (nearshore zone between high- and low-water marks). Common species in Cook Inlet are discussed below.

5.2.2.1 Pink Salmon

Pink salmon is typically the smallest salmon species in Cook Inlet, averaging between 3 and 5 pounds. Pink salmon enter their spawning streams between late June and October and typically spawn within a few miles of the shore, often within the intertidal zone. Most pink salmon spawn within a few miles of the coast, and spawning within the intertidal zone of the mouth of streams is very common The eggs are buried in the gravel of stream bottoms and hatch in the water. In spring, the young emerge from the gravel and migrate downstream to salt water. Pink salmon stay close to the shore during their first summer, feeding on small organisms such as plankton, insects, and young fish. At about one year of age, pink salmon move offshore to ocean feeding grounds where their food consists mainly of plankton, fish, and squid. Return migration to fresh water takes place during the second summer with few exceptions (SAIC 2002). The even-year pink salmon return is typically stronger than the odd-year return in Cook Inlet (ADF&G 1986). According to Fox and Shields(2004) the largest commercial catch of pink salmon occurred in 1964 with 3,231,961 salmon caught, compared to 30,436 pink salmon in 1963 and 23,963 in 1965. The average catch for the monitoring period 1956–2003 was 632,554 pink salmon, although this value is an average value for the period, the actual values from year to year differ drastically due to the even- and odd-year cycling.

5.2.2.2 Chum Salmon

Chum salmon grow to an average weight of between 7 and 18 pounds. Adult chum salmon are not well represented in west side Susitna drainages of Upper Cook Inlet. Chum production in the Susitna River declined in the mid-1980's to the mid-1990's but a steady increase in production has been observed in Upper Cook Inlet since the mid-1990's (Fox and Shields 2004). Chum salmon remain nearshore during the summer where their diet consists of small insects and plankton. In the fall, they start moving offshore where they feed on plankton. Chum return to fresh water in the fall and spawn late in the year, from approximately mid-September through mid-November.. Chum salmon enter the Cook Inlet region beginning in early July, and spawning continues through early August. Most chum salmon spawn in areas similar to those used by pink salmon, but sometimes travel great distances up large rivers (e.g., up to 3,218 km (2,000 miles) up the Yukon River). Chum salmon usually return to streams to spawn after 3 to 5 years at sea (SAIC 2002). Fox and Shields (2004) the highest commercially caught chum salmon in Cook Inlet occurred in 1982 when 1,432,940 chum salmon were harvested. The average catch for the monitoring period 1956–2003 was 534,651 chum salmon.

5.2.2.3 Sockeye Salmon

Sockeye salmon grow quickly and generally reach 4 to 8 pounds after 1 to 4 years. Approximately 50% of Susitna River sockeye are thought to be produced in the Yentna River tributary (Ivey and Sweet 2004). Sockeye salmon spawn in stream systems with lakes; fry may reside up to 3 years in fresh water lakes before migrating to sea. Maturing sockeye salmon return to freshwater streams during the summer months. Adult sockeye return to Cook Inlet and the Shelikof Strait region in late June, and runs continue through early August. Watersheds with lakes produce the greatest number of sockeye salmon. Most sockeye spend two to three winters in the North Pacific Ocean before returning to natal streams to spawn and die (SAIC 2002). Sockeye salmon is the most important commercial salmon species in Cook Inlet (ADF&G 1999). According to Fox & Shields (2004) the largest commercial catch occurred in 1987 when 9,465,994 sockeye were harvested. The average catch for the monitoring period 1956–2003 was 2,439,017 salmon.

5.2.2.4 Coho Salmon

Coho salmon grow to approximately 8 to 12 pounds. Adult coho salmon are well represented throughout Upper Cook Inlet (Rodrigues et al. 2006). The Susitna River drainage supports the largest coho stock in Upper Cook Inlet (Rodrigues et al. 2006). Coho salmon return to spawn in natal stream gravels from July to November, usually the last of the five salmon species. Run timing is regulated by water temperature at spawning grounds; where temperatures are low and eggs develop slowly, spawners demonstrate early run timing to compensate, and where temperatures are warm, adults are late spawners. Fry emerge in May or June and live in ponds, lakes, and stream pools, feeding on drifting insects (SAIC 2002). Coho salmon may reside in-stream up to three winters before migrating to the sea where they typically remain for two winters before returning to spawn (ADF&G 1986). According to Fox and Shields (2004) the highest commercial catch occurred in 1994 when 583,793 coho were caught commercially in Cook Inlet. The average catch for the monitoring period 1956–2003 was 305,119 coho salmon

5.2.2.5 Chinook Salmon

Chinook salmon are the largest of all Pacific Salmonids commonly exceeding 30 pounds each. Chinook reach the Susitna River in approximately mid-May (ADF&G 1986). Soon after hatching, most juvenile chinook salmon migrate to sea, but some remain for a year in fresh water. Most chinook salmon return to natal streams to spawn in their fourth or fifth year (SAIC 2002). The Susitna River supports the largest chinook salmon run in upper Cook Inlet which includes systems below the Forelands to the latitude of N 59º46′12″, near Anchor Point (ADF&G 1986). According to Fox and Shields (2004)Chinook peaked in 1987 with 39,431 salmon caught commercially in the Cook Inlet. The average for the monitoring period 1956–2003 was 17,713 Chinook salmon.

5.2.2.6 Steelhead Trout

Steelhead trout (*O. mykiss irideus*) is a rainbow trout that has spent a part of its life in the sea. These fish are unevenly distributed throughout Cook Inlet. Spawning begins in about mid-April and generally continues throughout May and early June. Steelhead trout usually spawn more than once. Eggs are deposited in gravel during the spring and develop into alevins or sac fry. By midsummer, they emerge from the gravel and seek refuge along stream margins and protected areas. Usually, juveniles remain in the parent stream for about 3 years before they enter saltwater (MMS 2003).

5.2.2.7 Cutthroat Trout

Cutthroat trout (*O. clarkii*) are the most common trout species in the region. Resident fish live in a wide variety of environments from small headwater tributaries and bog ponds to large lakes and rivers. Sea-run fish are usually found in river or stream systems with accessible lakes. It is unknown why some fish migrate to sea while others remain in fresh water. Adults spawn in small, isolated headwater streams from late April to early June, and young cutthroat trout emerge from the gravel in July. Sea-run cutthroat rear for 3 to 4 years in fresh water and then migrate to sea during May for a few days to more than 100 days before returning to their home stream (MMS 2003).

5.2.2.8 Bering Cisco

Bering cisco (*Coregonis laurettae*) have been reported in the Susitna River drainage (Barrett et al. 1985). Bering cisco enter river systems in the late summer. In 1982, spawning peaked mid-October in the Susitna River (SAIC 2002). Egg incubation occurs over winter and larvae move into northern Cook Inlet after ice-out in the spring from late April to May (Morrow 1980).

5.2.2.9 Dolly Varden Char

Dolly Varden Char (*Salvelinus malma*) that inhabit Cook Inlet can be anadromous or reside in fresh water. Non-resident Dolly Varden cycle seasonally between fresh water and marine environments. They often overwinter in fresh water drainages, then disperse into coastal waters during summer to feed on small fishes and marine invertebrates (Morrow 1980). In Cook Inlet, Dolly Varden spawn annually in rivers during the fall from late August to October (Scott and Crossman 1973; Morrow 1980). Like other salmonids, Dolly Varden lay eggs in hollowed out redds (shallow cavities dug into streambeds where salmonids spawn) located in swift moving water; hatching occurs the following spring. Juvenile Dolly Varden remain in their natal streams for 2 to 3 years (SAIC 2002).

5.2.2.10 White Sturgeon

White sturgeon (*Acipenser transmontanus*) are anadromous fish found in northern Cook Inlet. They are believed to spend most of life near shore in water depths of 30 meters or less (98 ft). Although little is known about white sturgeon migrations while in salt water, one tagged specimen was captured 1,056 km (656 miles) from where it was tagged (Morrow 1980). In the spring, most mature white sturgeon enter the estuaries and lower reaches of river systems. They spawn over rocky bottoms in swift water where the sticky eggs adhere to the river bottom. The amount of time needed for the eggs to hatch is not known (SAIC 2002). After spawning, the adults return to sea (Morrow 1980).

5.2.2.11 Eulachon

Eulachon (Thaleichthys pacificus) are small anadromous forage fish (up to approximately 23 cm [9 inches] long; MMS 1995) found throughout the Cook Inlet. Moulton (1997) reported that eulachon comprise 14.3% of the total catch in Upper Cook Inlet. Fechhelm et al. (1999) report that eulachon comprised 26.4 and 44.8% of the total catch near Chisik Island in May and August 1998, respectively. Mature eulachon, typically 3 years old, spawn in May soon after ice-out in the lower reaches of streams and rivers. The Susitna River supports a run of eulachon estimated in the millions (Barrett et al. 1985). Females broadcast their eggs over sand or gravel substrates where the eggs anchor to sand grains. Eggs hatch in 30 to 40 days, depending on the water temperature. Eulachon larvae are then flushed out of the drainage and mature in salt water. As juveniles and adults, they feed primarily on copepods and plankton. As the spawning season approaches, eulachon gather in large schools at stream and river mouths. Most eulachon die after spawning (Hart 1973). Eulachon is most important as a food source for other fish, birds, and marine mammals. The Cook Inlet population also supports small dipnet fisheries in upper Cook Inlet (SAIC 2002).

5.2.2.12 Saffron cod

Saffron cod is an important prey for some marine mammals, fishes, and birds (MMS, 1987b). These fish generally inhabit nearshore areas and enter rivers. Spawning occurs during the winter in nearshore waters (Morrow, 1980 cited in MMS, 1987b). Their occurrence in the Cook Inlet is limited. Studies by Moulton (1997) report that saffron cod comprise 1.4% of the total catch during Upper Cook Inlet tow sampling. Studies by Fechhelm et al. (1999) did not report saffron cod in Chisik Island area.

5.2.2.13 Pacific Herring

Pacific herring (Clupea pallasi) occur in large schools in the Cook Inlet region in early April and potentially through the early fall. Distribution and abundance in Cook Inlet is variable. These fish generally spawn during the spring. Spawning occurs in shallow, vegetated areas in intertidal and subtidal zones (MMS 2003). Female herring lay adhesive eggs over rock and seaweed substrates. Depending on water temperature, eggs hatch in 3 to 7 weeks. Herring stay nearshore until cold winter water temperatures drive them offshore to deeper, warmer waters. Herring have been harvested for bait in Cook Inlet as far north as the Forelands (Blackburn et al. 1979). The Cook Inlet herring fishery now targets Kamishak Bay on the west side of lower Cook Inlet. A small herring sac roe fishery has been suspended since the 1998 season because of low herring abundance. Alaska Department of Fish and Game (ADF&G) biologists observed about 8,100 tons of herring in the Kamishak Bay District in 2000; biomass must exceed a threshold of 8,000 tons before a commercial sac roe harvest can be considered for Kamishak Bay (SAIC 2002).

5.2.2.14 Pacific Sand Lance

Pacific sand lance (*Ammodytes hexapterus*) is a schooling fish that sometimes bury themselves in beach sand (Hart 1973). Pacific sand lance spawn within bays and estuaries, typically between December and March (SAIC 2002). Eggs are demersal, but will suspend in turbulent waters (Williams et al. 1964). Pacific sand lance larvae are found both offshore and in intertidal zones (Fitch and Lavenberg 1975; Kobayashi 1961). Early juvenile stages are pelagic, while the adult burrowing behavior develops gradually (Hart 1973). Major food items of the juvenile sand lance include copepods, other small crustaceans, and eggs of many forms (Hart 1973; Fitch and Lavenberg 1975). This species is commonly preyed upon by lingcod, Chinook salmon, halibut, fur seals, and other marine animals (Hart 1973) and appears to be an important forage species. Pacific sand lance have been caught off Chisik Island, southwest of West Foreland (Fechhelm et al. 1999).

5.2.2.15 Capelin

Capelin (*Mallotus villosus* [Muller]) is a major forage fish of the Cook Inlet region. Populations of capelin are large and are generally found in pelagic waters. They are mainly filter feeders, thriving on planktonic organisms including euphausiids and copepods. They spawn on beaches and in deeper waters and require specific conditions (e.g., temperature, tide, and light) for successful spawning. Capelin eggs attach to beach and bottom gravels. They hatch, depending on temperature, within 15 to 55 days. These fish currently have no economic value to Alaska, but they are used extensively for food by other fish, marine mammals, and seabirds (MMS 2003).

5.2.3 Groundfish

Groundfish is a term used to describe fish species that inhabit the seafloor during a portion of their life cycle, typically as adults. It is important to note that groundfish may exist as free swimming or planktonic larvae in a pelagic stage at some point during their lifecycle. Groundfish in the pelagic stages may serve as forage species for larger fish, and marine birds and mammals.

5.2.3.1 Pacific Halibut

The Pacific halibut (*Hippoglossus stenolepis*) is a large flatfish that occurs throughout Cook Inlet. Halibut concentrate on spawning grounds along the edge of the continental shelf at water depths of 182 to 455 m (597–1,493 ft) from November to March. Significant spawning sites in the vicinity of lower Cook Inlet are Portlock Bank, northeast of Kodiak Island, and Chirikof Island, south of Kodiak Island (IPHC 1998). Temperature influences the rate of development, but typically eggs hatch in 20 days at 5°C (41° F) (ADF&G 1986). As eggs develop into larvae, they float in the water column and drift passively with ocean currents. Halibut larvae's specific gravity decreases as they grow. Three- to 5-month old larvae drift in the upper 100 m (328 ft) of water where they are pushed by winds to shallow sections of the continental shelf. At 6 months old, juveniles settle to the bottom in nearshore waters where they remain for 1 to 3 years (Best and Hardman 1982). Juvenile halibut then move further offshore (IPHC 1998). Halibut migrate seasonally from deeper water in the winter to shallow water in summer. Accordingly, the fishery is most active in deep areas early in the season (i.e., May) whereas activity can be as shallow as 20 m (about 65 ft) during midsummer. A recreational fishery in central Cook Inlet targets Pacific halibut

(SAIC 2002). The Sport Fish Division of the ADF&G estimates that 74,803 and 117,900 halibut were caught by sport fishermen in central Cook Inlet and Lower Cook Inlet in 2012, respectively (ADF&G 2011)..

5.2.3.2 Pacific Cod

Pacific cod (*Gadus macrocephalus*) are distributed over lower Cook Inlet. Studies by Abookire et al. (2001) found that pacific cod were one of the most abundant species captured during sampling in Kachemak Bay. They are fast-growing bottom-dwellers that mature in approximately 3 years. They may reach lengths of up to 1 m (3.3 ft)(Hart 1973). Cod spawn during an extended period through the winter and eggs may hatch in 1 week depending on water temperature. Cod are harvested offshore in the Gulf of Alaska by trawl, longline, pot, and jig gear. Cod move into deep water in autumn and return to shallow water in spring. Pacific cod populations sustain a rapid turnover due to predation and commercial fishing (SAIC 2002). The Gulf of Alaska stock is projected to decline as a result of poor year-classes produced from 1990 to 1994 (Witherell 1999). Pacific cod abundance, in terms of biomass and numbers of fish, was assessed by the Gulf of Alaska bottom trawl survey conducted every two to three years over the time span of 1984 through 2011. This survey indicated decreased biomass of Pacific Cod from 1999-2007, before markedly increasing during the 2009 and 2011 surveys (Thompson et al. 2011).

5.2.3.3 Sablefish

Sablefish (*Anoplopama fimbria*) are also known as black cod. They are found within Cook Inlet; however most are harvested in deep water outside of Cook Inlet. Regardless, sablefish are a valued commercial species. These fish probably spawn during the spring, but little is known about their spawning behavior or egg-larval development. They feed on a large variety of benthic and pelagic fauna (MMS 2003).

5.2.3.4 Starry Flounder

Starry flounder (*Platichthys stellatus*) have been caught in central Cook Inlet (Fechhelm et al. 1999) and are likely to occur in northern Cook Inlet. Starry flounder spawn from February through April in shallow water (Hart 1973). They generally do not migrate, although one starry flounder was caught 200 km (124 miles) from where it had been tagged (Hart 1973). Starry flounder tolerate low salinities, and some have been caught within rivers (SAIC 2002).

5.2.3.5 Arrowtooth Flounder and Yellowfin Sole

Arrowtooth flounder (*Atheresthes stomias*) and yellowfin sole (*Pleuronectes asper*) may also extend into Cook Inlet. Little is known about the life history of these flatfish (SAIC 2002). Arrowtooth flounder larvae have been taken from depths of 200 m (about 650 ft) to the surface in June off British Columbia (Hart 1973). Both have been caught off Chisik Island in central Cook Inlet (Fechhelm et al. 1999).

5.2.3.6 Pacific Hake

Pacific hake (*Merluccius productus*) can be found throughout the Cook Inlet in small numbers. They could spawn up to several months in this region, with the pelagic eggs hatching in as little as 3 days depending on the size of the fish. Larvae hake consume copepods and other similarly-sized organisms while adult hake consume euphausiids, sand lance, anchovies, and other forage fishes. Hake are prey for other marine fish, marine birds, and marine mammals (MMS 2003).

5.2.3.7 Walleye Pollock

Walleye pollock (*Theragra chalcogramma*) are found throughout the Cook Inlet. Studies by Abookiere and Piatt (2005), Fechhelm et al. (1999) determined that in Lower Cook Inlet, most walleye pollock were caught in the Barren Island area and in Kachemak Bay and relatively few were caught near Chisik Island. Walleye pollock spawn in the spring in large aggregations and there is some extended spawning in smaller numbers throughout the year. Eggs hatch in about 10 to 20 days. Adult fish consume shrimp, sand lance, herring, small salmon, and similar organisms they encounter. Walleye pollock are also cannibalistic (MMS 2003).

Smaller numbers of Atka mackerel, and other groundfish inhabit Cook Inlet. These species generally are found in the same habitats as the groundfish species described above (MMS 2003).

5.2.4 Other Non-endangered Fish

Other nonendangered fish and invertebrate species found in Cook Inlet include: Pacific Ocean perch, rock sole, Alaska plaice, Rex sole, Dover sole, Flathead sole, Shortraker rockfish, Rougheye rockfish, Northern rockfish, Thornyhead rockfish, Yellowhead rockfish, Dusky rockfish, threespine stickleback and longfin smelt.

5.2.5 Growth and Production

A lack of overwintering habitat is the primary factor limiting arctic and sub-Arctic fish populations (ADNR, 1999).

Spawning in the arctic and sub-arctic environment can take place only where there is an ample supply of oxygenated water during winter. Because of this and the fact that few potential spawning sites can meet this requirement, spawning often takes place in or near the same area where fishes overwinter (MMS 2008).

Work conducted by Moulton (1997) in Upper Cook Inlet from the East and West forelands to Fire Island, not including Chickaloon Bay, Turnagain Arm, or Knik Arm, found the greatest mean fish densities occurred along the northwest shoreline from the Susitna delta to the North Forelands and the adjacent mid-channel waters. The study also determined that fish densities were greater in Upper Cook Inlet in June versus in July, and the lowest densities occurred along the southeastern shoreline from Moose Point to Boulder Point.

Limited information is available for the growth and production of salmon as juvenile salmon are not usually monitored by the ADF&G. Ocean growth of pink salmon is a matter of considerable interest because, although this species has the shortest life span among Pacific salmon, it also is among the fastest growing. Entering the estuary as fry at around 3 cm in length, maturing adults return to the same area 14-16 months later ranging in length from 45 to 55 cm.

5.2.6 Environmental Factors

The physical environment, mainly temperature and salinity, of the Arctic and sub-Arctic waters exerts a strong influence on the temporal and spatial distribution and abundance of fish including forage fish species in Kachemak Bay (MMS 1990, 1991; Abookire et al. 2000).

Because the feeding habits of marine fishes are similar to those of anadromous fishes, some marine fishes are believed to compete with migratory fishes for the same prey resources. Competition is most likely to occur in the nearshore brackish-water zone, particularly in or near the larger river deltas.

Infaunal prey density in the nearshore substrate is very low and provides little to no food for anadromous fishes. The nearshore feeding area also is much larger than that of freshwater habitats on the coastal plain (MMS 2003). For these reasons, both marine and anadromous fishes come to feed on the relatively abundant prey found in nearshore waters during summer.

In late summer when anadromous fishes are less abundant and their prey is more abundant, dietary overlap is common in nearshore waters (MMS 2003). Marine birds also compete for the same food resources during this time. Anadromous fishes do little to no feeding during their migration back to freshwater and when spawning, but some resume feeding during winter.

In the marine environment, pink salmon fry and juveniles are food for a host of other fishes and coastal sea birds. Subadult and adult pink salmon are known to be eaten by fifteen different marine mammals, sharks, other fishes such as Pacific halibut, and humpback whales. Because pink salmon are the most abundant salmon in the North Pacific, it is likely they comprise a significant portion of the salmonids eaten by marine mammals.

Additional factors such as prey availability and community structure, including associated bottom-up and top-down pressures within the Gulf of Alaska food-web that may affect fish populations. Bottom-up processes largely relate water temperature with crustacean densities and, thereby, influencing predatory fishes higher in the trophic web. Conversely, top-down processes also contribute to the community structure of the region. Piscivorous predators may limit or slow the ability of depressed forage fish populations from increasing (MMS 2003).

5.2.7 Fish Habitat

Cook Inlet contains Essential Fish Habitat (EFH) for a total of 35 species including walleye pollock, Pacific cod, and salmon. Routine operations and accidents can affect EFH by damaging habitats used for breeding, spawning, feeding, or growth to maturity (SAIC 2002). Additional information regarding EFH can be found in section 5.6.

Fishery management plans are obliged to identify habitat areas of particular concern (HPC) within EFH. HPCs include living substrates in shallow water that provide food and rearing habitat for juvenile fish and spawning grounds that may be impacted by shore-based activities. Estuarine and nearshore habitats of Pacific salmon (e.g., eelgrass [*Zostera sp*.] beds) and herring spawning grounds (e.g., rockweed [*Fucus sp*.] and eelgrass] are HPCs that can be found in Cook Inlet. Offshore HPCs include areas with substrates that serve as cover for organisms including groundfish. Areas of deepwater coral are also considered HPC, but populations are concentrated off southeast Alaska, out of the proposed project area. All anadromous streams qualify as HPC (SAIC 2002).

5.3 MARINE MAMMALS

5.3.1 Distribution and Abundance

Common marine mammals present in Cook Inlet include Beluga Whale, Minke Whale, Gray Whale, Killer Whale, Harbor Porpoise, Dall's Porpoise, Harbor Seal, Steller Sea Lion and other non-endangered species. These species are discussed below with reference to distribution and abundance in Cook Inlet.

All marine mammals in U.S. waters, including those also protected under the ESA, are protected under the Marine Mammal Protection Act of 1972. In the act, it was the declared intent of Congress that marine mammals "be protected and encouraged to develop to the greatest extent feasible commensurate with sound policies of resource management, and that the primary objective of their management should be to maintain the health and stability of the marine ecosystem." Species of marine mammals that are protected by the ESA within in the Cook Inlet will be discussed in section 5.5.

5.3.1.1 Minke Whale (Balaenoptera acutorostrata)

Minke whales occur in the North Pacific from the Bering and Chukchi Sea south to near the equator (Leatherwood et al. 1982). Minke whales are relatively common in the nearshore waters of the Gulf of Alaska (Mizroch 1992) but are not abundant in any other part of the eastern Pacific (Brueggeman et al. 1990). Minke whales are unlikely to migrate into Cook Inlet, but it is possible (SAIC 2002).

Minke whales breed in temperate or subtropical waters throughout the year (SAIC 2002). Peaks of breeding activity occur in January and June (Leatherwood et al. 1982). Calving occurs in winter and spring (Stewart and Leatherwood 1985). Females are capable of calving each year (SAIC 2002), but a 2-year calving interval is more typical (Leatherwood et al. 1982). Minke whales in the North Pacific prey mostly on euphausiids and copepods (SAIC 2002) but also feed on schooling fishes including Pacific sand lance, northern anchovy, and squid (Leatherwood et al. 1982; Stewart and Leatherwood 1985; Horwood 1990).

No estimates of the number of minke whales in the north Pacific or Alaskan waters have been made (Hill and DeMaster 2000). The annual human-caused mortality is considered insignificant (SAIC 2002). Minke whales in Alaska are not listed as depleted under the MMPA or considered a strategic stock (Hill and DeMaster 2000).

5.3.1.2 Gray Whale (Eschrichtius robustus)

Gray whales historically inhabited both the North Atlantic and North Pacific oceans. A relic population survives in the western Pacific. The eastern Pacific or California gray whale population has recovered significantly and now numbers about 23,000 (Hill et al. 1997). The eastern Pacific stock was removed from the Endangered Species List in 1994 and is not considered a strategic stock by the NMFS (SAIC 2002).

The eastern Pacific gray whale breeds and calves in the protected waters along the west coast of Baja, California and the east coast of the Gulf of California from January to April (Swartz and Jones 1981; Jones and Swartz 1984). At the end of the breeding and calving season, most of these gray whales migrate about 8,000 km (5,000 mi) north, generally along the west coast of North America, to the main summer feeding grounds in the northern Bering and Chukchi seas (SAIC, 2002).

Gray whale occurrences in Cook Inlet are uncommon. As they move through the Gulf of Alaska on their northward and southward migrations, gray whales closely follow the coastline (Calkins 1986). They generally tend to bypass Cook Inlet as they pass through the Barren Islands and the waters south of Kodiak Island (Calkins 1986). However, a cow and a calf were observed in lower Cook Inlet as recently as the summer of 2000 (personal communication, Eagleton 2000).

5.3.1.3 Killer Whale (Orcinus orca)

Killer whales occur along the entire Alaska coast (Dahlheim et al. 1997) from the Chukchi Sea, into the Bering Sea, along the Aleutian Islands, Gulf of Alaska, and into Southeast Alaska (Braham and Dahlheim 1982). Seasonal concentrations occur in Shelikof Strait and the waters around Kodiak Island (Calkins 1986). Killer whales are known to inhabit Cook Inlet waters during the summer and have been observed pursuing beluga whales in Cook Inlet (personal communication Eagleton 2000). Killer whales using Cook Inlet are most likely from the Eastern North Pacific Northern resident stock of killer whales (SAIC 2002). In 2000, the “resident” (i.e., fish consuming) stock minimum population estimate was 723 animals. In 2001, the “transient” (marine-mammal consuming) stock minimum population estimate was 346 animals (Angliss and Lodge 2004). Killer Whales are rare in Upper Cook Inlet. Shelden et al. (2003) reported 11 sightings of killer whales in Upper Cook Inlet from the Susitna Flats east into Turnagain Arm and north into Knik Arm over the last 20 years. Two of these sightings were recorded in the southern portion of Knik Arm. There were no killer whale sightings during two recent marine mammal studies in Upper Cook Inlet and Knik Arm (Funk et al. 2005; Ireland et al. 2005).

5.3.1.4 Harbor Porpoise (Phocoena phocoeana)

The harbor porpoise is distributed in waters along the continental shelf and is most frequently found in cool waters with high prey concentrations (Watts and Gaskin 1985). The range of the harbor porpoise within the eastern North Pacific Ocean is primarily restricted to coastal waters and extends from Point Barrow, along the coast of Alaska (SAIC 2002), and the west coast of North America to Point Conception, California (Gaskin 1984). They have been observed in Cook Inlet during winter months (Hansen and Hubbard 1999). Harbor porpoise densities are much greater in their southern range (Washington, northern Oregon and California) than in Alaskan waters (MMS 2003). Harbor porpoises are not migratory. Little information on the population dynamics of harbor porpoises is known; however, they occur in Cook Inlet (Calkins 1983). In 2000, the minimum population estimates for the Gulf of Alaska stock was 25,536 animals (Angliss and Lodge 2004). Dahlheim et al. (2000) estimated 136 animals during vessel-based surveys for an average density of 0.72 harbor porpoises per 100 km^2 (38.6 mi^2) for all of Cook Inlet in 1991. Harbor porpoises occur in Upper Cook Inlet throughout the year in small numbers but are more abundant in the lower inlet. The number of harbor porpoises in Knik Arm is unknown but appears to be low.

The major predators on harbor porpoises are great white sharks and killer whales. Unlike other delphinids, harbor porpoises forage independently, feeding on small schooling fishes such as northern anchovy as well as squid (SAIC 2002).

5.3.1.5 *Dall's Porpoise (Phocoenoides dalli)*

Dall's porpoises are widely distributed along the continental shelf (SAIC 2002) as far north as 65°N (Buckland et al. 1993) and are abundant throughout the Gulf of Alaska (Calkins 1986). Dall's porpoises prefer water depths greater than 20 m (66 ft) deep (SAIC 2002) and are commonly found in lower Cook Inlet (Calkins 1983). The only apparent gaps in their distribution in the Gulf of Alaska are in upper Cook Inlet and Icy Bay (Consiglieri and Braham 1982). The current estimate for the Alaska stock of Dall's porpoises (SAIC 2002) is 83,400 animals (Hill and DeMaster 1999). Dall's porpoises (MMS 2003) feed on squid, crustaceans, and deepwater fish (Leatherwood and Reeves 1987).

5.3.1.6 *Harbor Seal (Phoca vitulina richardsi)*

Harbor seals range from Baja California, north along the western coast of the United States, British Columbia, and Southeast Alaska, west through the Gulf of Alaska and the Aleutian Islands, and in the Bering Sea north to Cape Newenham and the Pribilof Islands. Hill and DeMaster (2000) estimated 29,000 individuals in the Gulf of Alaska stock (SAIC 2002). The Gulf of Alaska populations around Kodiak and Tugidak Islands have grown since the early 1990s (Small 1996; Withrow and Loughlin 1997) but overall, the stock numbers are in decline (Hill and DeMaster 2000). They are distributed in coastal waters along virtually the entire lower Cook Inlet coastline and are generally nonmigratory. Current population estimates for Cook Inlet are 2,244 (MMS 2003).

Harbor seals inhabit estuarine and coastal waters, hauling out on rocks, reefs, beaches, and glacial ice flows. They are generally nonmigratory, but move locally with the tides, weather, season, food availability, and reproduction activities (Scheffer and Slipp 1944; Fisher 1952; Bigg 1969; Bigg 1981). Female harbor seals give birth to a single pup while hauled out on shore or on glacial ice flows. The mother and pup remain together until weaning occurs at 3 to 6 weeks (Bishop 1967; Bigg 1969). Little is known about breeding behavior in harbor seals. When molting, seals spend the majority of the time hauled out on shore, glacial ice, or other substrates. Harbor seals consume a variety of prey in estuarine and marine waters. Prey type varies regionally and seasonally in the Gulf of Alaska. Walleye pollock are the dominant prey in the eastern Gulf, and octopus are the dominant prey in the western Gulf (SAIC 2002).

5.3.1.7 *Steller Sea Lion (Eumetopias jubatus)*

The Steller sea lion is distributed around the North Pacific Ocean rim from northern Hokkaiddo, Japan through the Kuril Islands and Okhotsk Sea, Aleutian Islands and central Bering Sea, southern coast of Alaska and south to the Channel Islands, California. The population is divided into Western and Eastern Stock at 144° W longitude. The western stock is the species includes Cook Inlet populations. This species is listed as "endangered" under the Environmental Species Act and "depleted" under the Marine Mammal Protection Act.

In 1956-60, the population of sea lions in the Gulf of Alaska and Aleutian Islands was estimated at 140,000 (Merrick et al. 1987. The number of Steller sea lions in the western stock declined by 75% between 1976 and 1990. In the 1990s, the decline continued for the western stock in Alaska. Counts at trend sites during 2000 indicate that the number of sea lions in the Bering Sea/Aleutian Islands region has declined 10.2% between 1998 and 2000. The most recent minimum estimate of stocks (2001-2002) indicates that this population was roughly 34,779 animals, including pups (Angliss and Lodge 2004).

5.3.1.8 Other Nonendangered Marine Mammals

Occasionally, Pacific walruses are sighted in the Cook Inlet area. These unusual sightings generally occur during the winter or spring during years when the Bering Sea pack ice extends into the southern Bering Sea and near the Aleutian Islands. Stray walruses apparently move through the passes into the Gulf of Alaska/Shelikof Strait into Cook Inlet (MMS 2003).

Other nonendangered marine mammals that rarely or infrequently occur in the Gulf of Alaska and Cook Inlet region (MMS 2003), include the short-finned pilot whale, Risso's dolphin, northern right whale dolphin, north Pacific giant bottlenose whale, goosebeak whale, and Bering Sea beaked whale (Consiglieri et al. 1982).

5.3.2 Growth and Production

5.3.2.1 Beluga Whales

Beluga whales season has been estimated from mid-May to mid-July (Calkins 1983). Calving is believed to take place in Kachemak Bay in the lower inlet in April and May, off the Beluga and Susitna Rivers in May, and in Chikaloon Bay seasonally during the summer (Huntington 2000). With a 14 to 15 month gestation period, beluga whales generally breed on a three-year cycle. While a third of the adult females are calving, a third is carrying a fetus, and the other third is not pregnant (often tending a calf that nurses for one to two years) (Braham 1984; Burns and Seaman, 1985). Females reach sexual maturity in 4 to 7 years, while males are sexually mature in 7 to 9 years.

5.3.2.2 Minke Whale

Minke whales breed in temperate or subtropical waters throughout the year (SAIC 2002). Peaks of breeding activity occur in January and June (Leatherwood et al. 1982). Calving occurs in winter and spring (Stewart and Leatherwood 1985). Females are capable of calving each year (SAIC 2002), but a 2-year calving interval is more typical (Leatherwood et al. 1982).

5.3.2.3 Gray Whale

The eastern Pacific gray whale breeds and calves in the protected waters along the west coast of Baja, California and the east coast of the Gulf of California from January to April (Swartz and Jones 1981; Jones and Swartz 1984). At the end of the breeding and calving season, most of those gray whales migrate about 8,000 km (5,000 mi) north, generally along the west coast of North America, to the main summer feeding grounds in the northern Bering and Chukchi seas (SAIC 2002).

5.3.2.4 Killer Whale

Killer whale peak breeding period is May through July (Nishiwaki and Handa 1958, as cited by Consiglieri et al. 1982). However, some groups are known to calve year-round (Reeves et al. 2002). Males live 50-60 years and females may live to 90 years of age.

5.3.2.5 Harbor Porpoise

Little is known about Harbor porpoise reproductive behavior, although mating occurs in summer and births occur between May and July (NMML undated).

5.3.2.6 Dall's Porpoise

For both sexes of Dall's porpoise, the average age at physical maturity was determined to be 7.2 years (Ferrero and Walker 2006). Dall's porpoise calves are born in mid-summer after a 12 month gestation period. They are about 3 ft (0.9 m) long. Calves and their mothers live separate from main porpoise herds for a time. Dall's porpoise mothers usually have calves every 3 years.

5.3.2.7 Harbor Seal

Female harbor seals give birth to a single pup while hauled out on shore or on glacial ice flows. The mother and pup remain together until weaning occurs at 3 to 6 weeks (Bishop 1967; Bigg 1969). Little is known about breeding behavior in harbor seals.

5.3.2.8 Steller Sea Lion

Pitcher and Calkins (1981) determined that the timing for key Steller sea lion reproductive events in the Gulf of Alaska were birth, mid-May to mid-July, breeding, late-May to mid- or late- July and implantation, late-September and October. Males mature between 3 and 8 years of age. Females mature between 2 and 8 years of age.

5.3.3 Environmental Factors

Stranding events, predation, availability of prey, disease, under-ice entrapment, and human impacts from subsistence/commercial fishing, by-catch, contamination, and anthropogenic noise disturbances can directly or indirectly affect marine mammal populations in Cook Inlet.

Stranding events are fairly common with 804 beluga whale stranding's and 129 reported mortalities in Upper Cook Inlet (primarily Turnagain Arm) since 1988 (NMFS 2005b). Stranding events may occur due to predation from killer whale or from natural causes.

Recent studies have determined that diseases caused by viral, bacterial and parasitic pathogens cause documented cases of mortality in marine mammals. The best documented case of viral infection was the European Seal Epizootic that killed more than 20,000 animals and over 50 percent of the North Sea harbor seal population in 1988 and 1989. This disease reoccurred in 2002 with a similar estimated number of dead and was caused by a distemper virus similar to the one that causes distemper in dogs. The virus had never been seen previously in marine mammals and is presumed to have evolved from the dog virus. Diseases in Cook Inlet beluga diseases can be caused by bacteria, viruses, fungi, protozoans, and parasites (URS 2010) Limited information is available regarding beluga mortality in relation to disease, as mortality is sometimes attributed to other causes. However, necropsies by Burek and Goertz (2010) identified disease as the primary cause of death in two Cook Inlet beluga deaths (out of 34 examined carcasses).

Entrapment in ice in winter is an occasional cause of whale mortality. At least 41 blue whales were reported caught in the ice along the West Coast of Newfoundland between 1869 and 1992. In 77% of these cases entrapment proved fatal for the animal (Sears and Calambokidis 2002).

5.4 COASTAL AND MARINE BIRDS

5.4.1 Distribution and Abundance

Migratory birds are a significant component of the marine ecosystem of the Cook Inlet. More than 100 species of birds may occur in Cook Inlet, including 39 species of seabirds, 35 loon, grebe, and waterfowl species; and 28 shorebird species (MMS 2003).

The Cook Inlet provides foraging, nesting, and rearing areas for several million birds each year. Surveys conducted by Piatt (1994) in lower Cook Inlet (ca. 12,500 km^2 [4826 mi^2]) estimated that during the 1992 survey period more than 2 million seabirds foraged within the 50 km (31 mi) area of Barren Island in July, and these waters supported an average seabird biomass of 89.8 kg/km^2 (512 lb/mi^2). Transient shearwaters (64.4 kg/km^2 [367 lb/mi^2]) comprised most of this standing biomass, but coastal/shelf species (12.8 kg/km^2 [73 lb/mi^2]) and oceanic species (6.5 kg/km^2 [37 lb/mi^2]) contribute to make lower Cook Inlet one of the most productive areas for seabirds in Alaska (compare with 17.1 kg/km^2 [97.5 lb/mi^2] in Bering Strait, or 36.1 kg/km^2 [206 lb/mi^2] on the outer shelf of the southeast Bering Sea). Seabird densities were highest in the vicinity of the Barren and Shuyak islands and their associated shelf environments.

Common species observed by Piatt (1994) in lower Cook Inlet during July study period included Short-tailed Shearwaters *Puffinus tenuirostris* (66% of birds observed), Fork-tailed Storm-petrel (7.3%), phalaropes (6.6%), Northern Fulmar (5.6%), Tufted Puffin (5.5%), murres (3.6%), Black-legged Kittiwake (2%) and murrelets (1.6%). The following groups of birds will be discussed below with reference to distribution and abundance in Cook Inlet: seabirds, shorebirds, waterfowl, and coastal birds of prey. Species of coastal and marine birds that are protected by the ESA within in the Area of Coverage will be discussed in Section 5.5.

According to a literature review (MMS 2003), within the lower Cook Inlet area, the largest concentration of seabirds occurs in the Barren Islands. Recent counts and estimates of seabirds on the Barren Islands (Kettle 2003 personal communication; Roseneau et al. 2000), supplemented by earlier census data (Bailey 1976; Simons and Pierce, 1978), indicate a total of nearly 420,000 breeding seabirds for these colonies. The author suggests that actual populations may be substantially larger and actual breeding population in Barren Islands of at least 500,000 birds and possibly more. Cook Inlet seabird colonies also occur at the Chisik-Duck Islands on the west side of the Inlet (about 30,000 birds) and on Gull Island in Kachemak Bay (about 20,000 birds) (MMS 2003). Smaller colonies are present in Kamishak Bay and on northwestern Afognak and western Shuyak islands (Sowls, Hatch, and Lensink 1978; Bailey and Faust 1982).

Kachemak Bay was identified recently as a Western Hemisphere Shorebird Reserve because of its importance to shorebirds of the Pacific Flyway.

The most abundant waterfowl species in the lower Cook Inlet include scoters, long-tailed ducks, eiders, and goldeneyes (Agler et al. 1995). Among the shorebirds, western sandpipers, rock sandpipers, and dunlins predominate in the lower Inlet at various seasons (Gill and Tibbitts 1999).

5.4.1.1 Seabirds

Lower Cook Inlet is one of the most productive areas for seabirds in Alaska. Approximately 27 species, composed of an estimated 100,000 seabirds (USFWS 1992), occur in Cook Inlet, and about 18 species breed in the Inlet. Seabird breeding colonies occur along the coastline of the Gulf of Alaska and the lower Cook Inlet (DeGange and Sanger 1987; USFWS 1992). Species breeding in lower Cook Inlet include glaucous-winged gulls; black-legged kittiwake; common murre; pigeon guillemot; horned and tufted puffins; parakeet auklet; and red-faced, double-crested, and pelagic cormorants (SAIC 2002). Large seabird concentrations (about 30,000 birds) on the west side of Cook Inlet occur at the Chisik-Duck Islands (MMS 2003).

Large concentrations of seabirds occur in Cook Inlet and the Gulf of Alaska during the spring when returning breeding species and migrants from breeding grounds in the southern hemisphere move into the area. The numbers remain high throughout the summer and decline in the fall as they begin to migrate to their wintering grounds (DeGange and Sanger 1987). Seabird numbers in Cook Inlet are lowest during the winter (SAIC 2002). Major prey species for seabirds during the spring and summer seasons in the Cook Inlet area (MMS 2003) include capelin, pollock, sand lance, herring, euphausiid crustaceans, and squid (Baird and Moe 1978; Sanger et al. 1978; Hatch 1984; Baird 1991; Piatt 2002).

5.4.1.2 Shorebirds

Approximately 30 shorebird species occur as breeding birds and migrants in Cook Inlet. Although shorebirds nest in Cook Inlet, the most important areas for shorebird use are the migratory stopover areas in the northern Gulf of Alaska/lower Cook Inlet where birds stop to rest and feed. An important location for shorebirds during migration is western Cook Inlet (DeGange and Sanger 1987). These include the intertidal zones of Drift River, Iniskin Bay, and Chinitna Bay. Kachemak Bay in lower Cook Inlet is also an important feeding and resting area for shorebirds during migration (SAIC 2002).

The Pribilof Islands rock sandpiper (*Calidris ptilocnemis*) winters along the intertidal mudflats from the Susitna River south to Redoubt Bay (Gill and Tibbets 1999). The sandpipers, which begin arriving in November and remain through mid-April, feed on a small bivalve (*Macoma balthica*) found in high densities in the intertidal area. The mean count of the Pribilof Island rock sandpiper during aerial surveys conducted in winter (1997 to 1999) was 17,530 birds (MMS 2003).

During spring migration, millions of shorebirds congregate at coastal intertidal mudflats to feed before continuing their northward migration. Most birds pass through the area between late April and mid-May with the peak of the migration in early May. The two most common species are dunlin and western sandpiper. Turnover is high, and individual birds probably only stop to feed and rest for a few days before continuing (SAIC 2002).

5.4.1.3 Waterfowl

The most abundant waterfowl species in lower Cook Inlet (MMS 2003) include scoters, long-tailed ducks, eiders, and goldeneyes (Agler et al. 1995). Large numbers of waterfowl migrate through the Cook Inlet area in the spring (Arneson 1980; Gill and Tibbitts 1999). Waterfowl densities increase in winter and are higher in eastern Cook Inlet than on the western side (Arneson 1980).

A September aerial survey conducted by Larned (2005) in the lower Cook Inlet found that by far the most numerous of the seaducks were the surf and white-winged scooters. Populations of the surf and white-winged scooters were estimated at 3,734 and 2,876 birds respectively. These species were found primarily in bays and along the shoreline from Chinitna Bay to Ursus cove, with a few further south near Douglas River. Sea ducks feed primarily on benthic invertebrates, including clams and mussels (Sanger and Jones 1984).

The September survey by Larned (2005) also targeted molting flocks of Steller's eiders and mergansers. A total of seven flocks of Steller's eiders in the vicinity of the Douglas River Delta were found. The largest flock was estimated at 1,800 birds, and the total of all Steller's eider flocks was estimated to be 2,190 birds. The author suggests that the shoals and reefs near the Douglas River in Kamishak Bay are an important molting habitat for Steller's eiders, and likely the only important such habitat in Cook Inlet. Only a single congregation of molting mergansers was detected, estimated at 500 birds, also in the Douglas River area. No Steller's eiders or mergansers were recorded along the eastern shoreline of Cook Inlet. The author concludes that the Douglas River Shoals is the only likely habitat in the surveyed portion of the Lower Cook Inlet supporting a large molting population of mergansers (Larned 2005).

5.4.1.4 Coastal Birds of Prey

The bald eagle is a breeding, year-round resident along the coast of lower Cook Inlet (MMS 1995). Populations in southeastern Alaska have been stable or increasing. Bald eagles feed primarily on fish or act as scavengers (MMS 2003).

Peregrine falcon occur along the coast in the Gulf of Alaska south to British Columbia. Some nesting is known to occur on the Barren Islands (Bailey, 1976 as cited by MMS 2003). High nest site densities of peregrine falcons were also found along the southern coast of the Kenai Peninsula. Estimates for the Kenai Peninsula populations were more than 60 adults for the southern peninsula (Hughes and Sanger 1999 as cited by MMS 2003).

5.4.2 Growth and Production

Some seabird populations in the Gulf of Alaska have declined markedly during the past few decades (Hatch and Piatt 1995; Piatt and Anderson 1996). These declines may be due to food stress including population declines, decreased productivity, changes in diet, and large-scale die-offs (Piatt 2002), environmental changes such as the Exxon Valdez oil spill, and other factors that are less clearly understood (Piatt 2002).

Population trends in seabird colonies appear to be related to differences in food availability. In the late 1970s, a significant regime shift occurred in the Gulf of Alaska, characterized by changes in seawater temperature and decreases in abundance of forage fish; this resulted in reduced food availability to seabirds, lower reproductive success, large-scale die-offs, and long-term decreases in some populations (Piatt and Harding 2007). In fact, although the 1989 Exxon Valdez oil spill had a serious and immediate impact on seabird populations, effects of the regime shift are considered to have had an even more significant effect (Piatt and Harding 2007).

Studies of seabird colonies in the Cook Inlet area by Piatt (2002) indicated that the breeding biology of seabirds differed drastically among colonies based on geographic differences in forage fish abundance. For example birds at Chisik Island struggled to reproduce, while those at Gull and Barren islands usually had few problems rearing young. Breeding and behavioral parameters were found to be similar among years during the study period (1995 – 1999) with the exception of 1 year (1998) when breeding success for all species was lower than the other years in the study. These patterns were noted to continue as seabirds populations at Chisik Island continued to decline and populations at Gull and Barren islands stable or increasing with time.

Shorebird populations are primarily migratory, appearing in the Cook Inlet in early May and leaving by late May. Few shorebirds use the intertidal habitat of Knik Arm (URS Corp 2006 as cited by MMS 2003).

5.4.3 Environmental Factors

Shifts to earlier laying dates could result in overall decreased clutch size or chick survival if nutritional needs are outside the period of favorable food conditions (Visser, Both, and Lambrechts 2004). In this case, climate change could lead to mistiming and failure of reproduction and certain marine and coastal bird populations could decline (MMS 2008).

The highest nesting densities generally occur in areas of mixed wet and dry habitats, whereas birds often move to wetter areas for broodrearing. Islands in river deltas provide the principal nesting habitat for several waterfowl and marine bird species. Shorebirds prefer well-drained gravelly areas for nesting, whereas loons use lakes, and geese prefer deeper ponds or wet tundra near lakes. Lagoons formed by barrier islands, bays, and river deltas provide important broodrearing and staging habitat for waterfowl, particularly molting oldsquaws. Peregrine falcons, bald eagles, and Canada geese nest primarily on bluffs. Arctic peregrine falcons are common in the Gulf of Alaska and are considered a species of special concern by the State of Alaska because of population declines (ADF&G 2008 as cited in ADNR 2009).

Emergent and wetland vegetation such as various sedges are the primary food types for most waterfowl. Invertebrates in brackish and freshwater flats and ponds are the principal food sources for shorebirds. Phalaropes, terns, auklets, murres and kittiwakes feed on zooplankton (MMS 1982, 1987a). Parakeet auklets also prey on a variety of pelagic invertebrates and occasional small fish. Thick-billed murres, common murres, black-legged kittiwakes, horned puffin, and pelagic cormorant prey on fish (sand lance, arctic cod, and prickleback) during the nesting season (MMS 1982). The reproductive success of black-legged kittiwakes is greatly dependent on the availability of sand lance during the chick-rearing period (Drury 1978). Black guillemots eat all kinds of animals from the sea, including crustaceans (crabs and shrimp), mollusks (clams and snails), and worms. The black-crowned night heron is an opportunistic feeder; its diet consists mainly of fish, though it is frequently rounded out by other items such as leeches, earthworms, aquatic and terrestrial insects. It also eats crayfish, mussels, squid, amphibians, lizards, snakes, rodents, birds, eggs, carrion, plant materials, and garbage and refuse at landfills.

5.4.4 Coastal and Marine Bird Habitat

Piatt (1994) discusses that at small spatial scales (1-100 km [0.6 – 62 mi]), seabirds may aggregate where food is concentrated at fronts (e.g., Brown and Gaskin 1988, Piatt et al. 1991, Schneider et al. 1990), which may be defined as areas of high spatial gradient in thermodynamic properties such as temperature, density, or velocity (Schneider 1990). At both small and medium (100-1000 km [62 – 621 mi]) spatial scales, seabird species or "assemblages" may not necessarily be concentrated at fronts, but rather be segregated into different water masses which are themselves demarcated by fronts (Schneider et al. 1986, 1987; Gould and Piatt 1993). Strong fronts may attract more seabirds than weak fronts (Schneider et al. 1987), seabird abundance may be correlated with the spatial extent or frequency of fronts (Haney and McGillivary 1985), and strongly demarcated water masses may promote greater segregation of seabird species than weakly defined ones (Elphick and Hunt 1993).

5.5 THREATENED AND ENDANGERED SPECIES

Section 7(a)(2) of the ESA of 1973 requires federal agencies, in consultation with the agencies responsible for administering the ESA, the NMFS and the USFWS, to ensure that any action they authorize is not likely to jeopardize the continued existence and recovery of any species listed as threatened or endangered or result in the destruction or adverse modification of critical habitat. An endangered species is defined as a species that is in danger of extinction throughout all or a significant portion of its range. A threatened species is defined as a species that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range (Tetra Tech 2005).

The threatened and endangered species listed below in table 5-1 may be present near the proposed project and are discussed below in relation to geographic boundaries and spatial distribution, critical habitat, life history, and population trends and risks.

Table 5-1. Species Listed Under the ESA within the Geographic Area Included in the Proposed Action

Species	Population/Stock	Present Status	*Federal Register* Notice	
Chinook Salmon (*Oncorhynchus tshawytscha*)	Snake River fall run	Threatened	57 FR 14653	04/22/92
	Snake River spring/summer run	Threatened	57 FR 14653	04/22/92
Sockeye Salmon (*Oncorhynchus nerka*)	Snake River	Endangered	56 FR 58619	11/20/91
Short-tailed Albatross (*Phoebastria albatrus*)	U.S. waters	Endangered	65 FR 46643	7/31/00
Steller's Eider (*Polysticta stelleri*)	Alaska	Threatened	62 FR 31748	6/11/97

Table 5-1. Species Listed Under the ESA within the Geographic Area Included in the Proposed Action				
Species	**Population/Stock**	**Present Status**	***Federal Register* Notice**	
Blue Whale (*Balaenoptera musculus*)	North Pacific	Endangered	35 FR 8495	6/2/70
Fin Whale (*Balaenoptera physalus*)	Northeast Pacific	Endangered	35 FR 8491 35 FR 8498	6/2/70 6/2/70
Humpback Whale (*Megaptera novaeangliae*)	Central/Western North Pacific	Endangered	35 FR 8491	6/2/70
Northern Right Whale (*Eubalaena japonica*)	Eastern North Pacific	Endangered	35 FR 8495 68 FR 17560	6/2/70 4/10/03
Sei Whale (*Balaenoptera borealis*)	North Pacific	Endangered	35 FR 8498	6/2/70
Sperm Whale (*Physeter macrocephalus*)	North Pacific	Endangered	35 FR 8495	6/2/70
Beluga Whale (*Delphinapterus leucas*)	Cook Inlet	Endangered	73 FR 62919	10/22/08
Northern Sea Otter (*Enhydra lutris*	Southwest Alaska	Threatened	70 FR 46366	8/9/05
Steller Sea Lion (*Eumetopias jubatus*)	Western (West of 144 W longitude) Eastern (East of 144 W longitude)	Endangered Threatened	62 FR 24355 62 FR 24345	5/5/97 5/5/97

5.5.1 SNAKE RIVER FALL CHINOOK SALMON (*Oncorhynchus tshawytscha*)

Chinook salmon are anadromous and semelparous, meaning that as adults they migrate from a marine environment into the fresh water streams and rivers of their birth (anadromous) where they spawn and die (semelparous). Seasonal "runs" (i.e., spring, summer, fall, or winter) have been identified on the basis of when adult Chinook salmon enter fresh water to begin their spawning migration. Because genetic analyses indicate that fall-run Chinook salmon in the Snake River are a distinct evolutionarily significant unit (ESU) from the spring/summer-run in the Snake River Basin (Waples et al. 1991), Snake River fall-run Chinook salmon are considered separately. NMFS clarified the status of both ESUs as threatened in 1992 (57 FR 14653).

Two distinct races have evolved among Chinook salmon. The "stream-type" race of Chinook salmon, is found most commonly in headwater streams. These salmon maintain a longer fresh water residency, and demonstrate extensive offshore migrations into the North Pacific before returning to their natal streams in the spring or summer months (Healey 1991, 55 FR 11482). The "ocean-type" Chinook, including the Snake River fall-run Chinook salmon ESU, are commonly found in coastal streams in North America. Ocean-type Chinook migrate to sea where they tend to spend their ocean phase in coastal waters within approximately 1,000 km (621 mi) of their natal river (Healy 1991, 55 FR 11482). Ocean-type Chinook salmon return to their natal streams as spring, winter, fall, summer, and late-fall runs, but summer and fall predominate. The difference between these life history types is also physical, with both genetic and morphological foundations (55 FR 11482).

5.5.1.1 Geographic Boundaries and Spatial Distribution

The Snake River includes the mainstem and all tributaries, from the confluence with the Columbia River to the Hells Canyon Dam complex. Stock-specific information on spatial and temporal distribution of Snake River Chinook salmon within the marine environment are primarily based on the recovery of coded-wire tagged Chinook salmon under the U.S. North Pacific Groundfish Observer Program. These observations indicate that North American Chinook salmon, including the Snake River ESUs, range across almost the entire Bering Sea, north to 60°03'N and west to 172°12'E. In the North Pacific, the known ocean range extends north from about 40°N (in the coastal waters just off California) and west to the waters just south of Adak Island in the central Aleutians (176°34'W, 51°29'N) (HSSRP 2004).

5.5.1.2 Critical Habitat

Critical habitat for the Snake River fall Chinook salmon was listed on December 28, 1993 (58 FR 68543) and modified on March 9, 1998 (55 FR 11482), to include the Deschutes River in Oregon. The designation does not include any waters within the state of Alaska. It does include all river reaches accessible to Chinook salmon in the Columbia River from The Dalles Dam upstream to the confluence with the Snake River in Washington (inclusive). Within the Snake River system, it includes tributaries in Idaho, Oregon, and Washington (exclusive of the upper Grande Ronde River and the Wallowa River in Oregon, the Clearwater River above its confluence with Lobo Creek in Idaho, and the Salmon River upstream of its confluence with French Creek in Idaho). Also included are river reaches and estuarine areas in the Columbia River from a straight line connecting the west end of the Clatsop jetty (south jetty, Oregon side) to the west end of the Peacock jetty (north jetty, Washington side) upstream to The Dalles Dam. Areas above specific dams or above longstanding, naturally impassable barriers (e.g., natural waterfalls) are excluded (55 FR 11482).

5.5.1.3 Life History

Fall-run Chinook salmon in this ESU are ocean-type. Adults return to the Snake River at ages 2 through 5, with age 4 most common at spawning (Chapman et al. 1991). Spawning, which takes place in late fall, and occurs in the mainstem and in the lower reaches of major tributaries (NWPPC 1989, Waples et al. 1991). Juvenile fall-run Chinook salmon migrate to sea as sub-yearlings, typically within several weeks of emergence (Chapman et al. 1991).

5.5.1.4 Population Trends and Risks

The historical population of Snake River fall-run Chinook salmon is difficult to estimate. Irving and Bjornn (1981) estimated a population of 72,000 for the period of 1938 to 1949 that declined to 29,000 during the 1950s. During construction of the four lower Snake River dams, from 1962 to 1978, spawner abundance peaked at 18,000, then plummeted to less than 500 with the completion of Lower Granite Dam in 1974 (FPC 2011). Since that time, spawner abundance has increased significantly, with returns to Lower Granite Dam of more than 15,000 in 2008 and 41,185 in 2010, including an estimated 9,583 of natural origin (FPC 2011). For the Snake River fall-run Chinook salmon ESU, NMFS estimates that the median population growth rate (lambda) over a base period from 1980 through 1998 ranged from 0.94 to 0.86. The decrease in growth rate reflects the increased effectiveness of hatchery fish spawning in the wild compared with that of fish of wild origin (McClure et al. 2000).

Habitat loss is a significant threat to the Snake River salmon populations. Approximately 80 percent of all historical spawning habitat in the Snake River Basin became inaccessible with the completion of the Hells Canyon Dam complex (Ford et al. 2010). The ESU's range has also been adversely affected by agricultural water withdrawals, livestock grazing, and vegetation management within the Columbia and Snake River basins. More recently, the continued straying by nonnative hatchery fish into natural production areas is an additional source of risk.

5.5.2 SNAKE RIVER SPRING/SUMMER CHINOOK SALMON (*Oncorhynchus tshawytscha*)

5.5.2.1 Geographic Boundaries and Spatial Distribution

The contention that multiple ESUs exist within the Snake River Basin spring and summer runs is not clearly supported by data (CBFWA 1990); thus, the Snake River spring and summer Chinook salmon runs are considered and presented here as a single ESU.

The Snake River spring and summer Chinook salmon ESU comprises 5 major population groups (MPG; Grande Ronde/Imnaha, Lower Snake River, Middle Fork Salmon River, South Fork Salmon River, and South Fork Salmon River), with 28 extant populations (76 FR 50448). Stock-specific information on spatial and temporal distribution of Snake River Chinook salmon within the marine environment are limited and are primarily available from the recovery of coded-wire tagged Chinook salmon under the U.S. North Pacific Groundfish Observer Program. These observations indicate that North American Chinook salmon, including the Snake River spring/summer ESU, range widely across the North Pacific, extending from about 40°N (in the coastal waters just off California), north to the Gulf of Alaska and west to the waters just south of Adak Island in the central Aleutians (176°34'W, 51°29'N) (HSSRP 2004).

5.5.2.2 Critical Habitat

Critical habitat for the Snake River spring/summer Chinook salmon was established in 1993 (58 FR 68543). The area consists of river reaches of the Columbia, Snake, and Salmon Rivers, and all tributaries of the Snake and Salmon Rivers (except the Clearwater River) presently or historically accessible to Snake River spring/summer Chinook salmon (except reaches above impassable natural falls and Hells Canyon Dam).

5.5.2.3 Life History

The Snake River spring/summer-run Chinook salmon ESU are stream-type fish, with juveniles that migrate to sea as yearling smolts. Depending on location within the basin (and not on run type), adults tend to return after either 2 or 3 years in the ocean. Most Snake River spring/summer Chinook salmon enter individual sub-basins from May through September. Juveniles emerge from spawning gravel from February through June (Bjornn and Peery 1992). After rearing in their natal streams for about 1 year, smoltification occurs and the fish begin migrating seaward from April through May (Waples et al. 1991, Cannamela 1992).

5.5.2.4 Population Trends and Risks

Recent trends in redd counts in major tributaries of the Snake River indicate that many subpopulations could be at critically low levels. Subpopulations in the Grande Ronde River, Middle Fork Salmon River, and Upper Salmon River Basins are at particularly high risk. Both demographic and genetic risks would be of concern for such subpopulations, and in some cases, habitat may be so sparsely populated that adults have difficulty finding mates. NOAA Fisheries estimates that the median population growth rate (lambda) over a base period from 1980 through 1998 ranges from 0.96 to 0.80, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared with the effectiveness of fish of wild origin (Tables B-2a and B-2b in McClure et al. 2000). In 2002, the fish count at Lower Granite Dam was 75,025, more than double the 10-year average. Estimated hatchery Chinook at Lower Granite Dam accounted for a minimum of 69.7 percent of the run. The spring Chinook count in the Snake River was at the all-time low of about 1,500 as recently as 1995, but in 2001 and 2002, both hatchery and wild/natural returns to the Snake River increased (FPC 2003).

5.5.3 SNAKE RIVER SOCKEYE SALMON (*Oncorhynchus nerka*)

5.5.3.1 Geographic Boundaries and Spatial Distribution

Snake River sockeye salmon, considered to be an ESU, were listed as endangered under the ESA on November 20, 1991 (56 FR 58619). Currently, the only remaining anadromous sockeye population in the Snake River system is found in Redfish Lake, on the Salmon River. The non-anadromous form (kokanee), found in Redfish Lake and elsewhere in the Snake River Basin, is included in the ESU. Snake River sockeye were historically abundant in several lake systems of Idaho and Oregon. However, all populations have been extirpated in the past century, except fish returning to Redfish Lake.

Sockeye salmon in the Cook Inlet are not considered to be an endangered species and are far more prevalent than those stocks in the Snake River. The ADF&G estimates that a run of 6.2 million sockeye salmon is forecasted to return to Upper Cook Inlet in 2012 (ADF&G 2012). Forecasted sockeye salmon runs to individual freshwater systems are as follows: Crescent River 81,000; Fish Creek 84,000; Kasilof River 754,000; Kenai River 4,026,000; Susitna River 443,000 (ADF&G 2012). The forecasted runs for each of the aforementioned freshwater systems are below the 20-year average runs of fish returning to the system (ADF&G 2012).

The most abundant North American sockeye salmon stocks occur in the Bristol Bay region of western Alaska. Note that the sockeye salmon is not considered as threatened or endangered in the Bristol Bay region. Recoveries of high-seas tagged sockeye salmon in North America show them to be broadly distributed across the North Pacific Ocean and Bering Sea. There are many fewer recoveries for immature than for maturing North American sockeye salmon, and the known range of maturing fish extends further to the southwest than that of immature fish. The known range of Bristol Bay sockeye salmon is much broader (particularly in the Bering Sea) than that of more southerly stocks (HSSRP 2004). Limited information is available describing the distribution of Snake River sockeye salmon in the marine waters. It appears that there is considerable overlap in the migratory distribution of sockeye salmon originating in rivers of the northeastern Pacific Ocean from the Columbia River to the Alaska Peninsula (Burgner 1991). While their ranges overlap, British Columbia-Washington stocks tend to be distributed farther to the south than Alaskan sockeye stocks with the northernmost extension to the general area south and east of Kodiak Island (Burgner 1991).

5.5.3.2 Critical Habitat

The critical habitat for the Snake River sockeye salmon was designated on December 28, 1993 (NMFS 1993a). The designated habitat consists of river reaches of the Columbia, Snake, and Salmon Rivers, Alturas Lake Creek, Valley Creek, and Stanley, Redfish, Yellow Belly, Pettit, and Alturas Lakes (including their inlet and outlet creeks).

5.5.3.3 Life History

Snake River sockeye salmon enter the Columbia River primarily during June and July. Arrival at Redfish Lake peaks in August and spawning occurs primarily in October (Bjornn et al. 1968). Eggs hatch in the spring between 80 and 140 days after spawning. Fry remain in the gravel for 3 to 5 weeks, emerge in April through May, and move immediately into the lake where juveniles feed on plankton for 1 to 3 years before migrating to the ocean. Migrants leave Redfish Lake from late April through May (Bjornn et al. 1968), migrating almost 900 miles to the Pacific Ocean. Out-migrating juveniles pass Lower Granite Dam (the first dam on the Snake River downstream from the Salmon River) from late April to July, with peak passage from May to late June. Once in the ocean, the smolts remain nearshore or within the Columbia River influence during the early summer months. Later, they migrate through the northeast Pacific Ocean (Gustafson et al. 1997, Hart 1973). Snake River sockeye salmon usually spend 2 to 3 years in the Pacific Ocean and return to the Snake River in their fourth or fifth year of life.

5.5.3.4 Population Trends and Risks

Snake River sockeye salmon returns to Redfish Lake since at least 1985, when the Idaho Department of Fish and Game began operating a temporary weir below the lake, have been extremely small (1 to 29 adults counted per year). Snake River sockeye salmon have a very limited distribution relative to critical spawning and rearing habitat. Redfish Lake represents only one of the five Stanley Basin lakes historically occupied by Snake River sockeye salmon. NMFS proposed an interim recovery level of 2,000 adult Snake River sockeye salmon in Redfish Lake and two other lakes in the Snake River Basin (NMFS 1995a). Because only 16 wild and 264 hatchery-produced adult sockeye returned to the Stanley River Basin between 1990 and 2000, NMFS considers the risk of extinction of this ESU to be very high. In 2002, 52 adult sockeye were counted at Lower Granite Dam (FPC 2003). In 2003, 12 sockeye salmon had been counted at Lower Granite Dam on the Snake River (USACE 2003). In 2011, the number of sockeye counted at Lower Granite Dam on the Snake River increased to 1502 (FPC 2012).

Historically, the largest numbers of Snake River sockeye salmon returned to headwaters of the Payette River, where 75,000 were taken one year by a single fishing operation in Big Payette Lake. During the early 1880s, returns of Snake River sockeye salmon to the headwaters of the Grande Ronde river in Oregon (Walleye Lake) were estimated between 24,000 and 30,000 at a minimum (Cramer 1990). During the 1950s and 1960s, adult returns to Redfish Lake numbered more than 4,000 fish.

5.5.4 SHORT-TAILED ALBATROSS *(Phoebastria albatrus)*

The short-tailed albatross was listed as endangered in U.S. waters under the ESA on July 31, 2000 (65 FR 46643).

5.5.4.1 Geographic Range and Distribution

The short-tailed albatross once ranged throughout most of the North Pacific Ocean and Bering Sea with known nesting colonies on several islands within the territorial waters of Japan and Taiwan. The majority of breeding occurs on two remote islands in the western Pacific under Japanese jurisdiction. Approximately 80 to 85 percent of short-tailed albatrosses breed as part of a single colony, Tsubamezaki, on Torishima Island, an active volcano which is susceptible to mud slides and erosion (USFWS 2009). Recently, a new colony, Hatsunezaki, has formed on the northwest side of the island as a result of efforts by the Yamashina Institute for Ornithology in Japan (USFWS 2009). The location of this new colony presents a safer, more stable breeding area and, thus, is viewed as a significant conservation achievement for the species. The remaining known breeding birds nest in the Senkaku Island group almost exclusively on Minami-kojima (USFWS 2008). Other undocumented nesting colonies may also have existed in areas under U.S. jurisdiction on Midway Atoll and in the Aleutian Islands, but evidence for breeding on the Alaskan Aleutian Islands is lacking. Given the southerly location of known breeding grounds and midwinter constraints on breeding at high latitudes, Sherburne (1993) concluded that it is highly unlikely that short-tailed albatross ever reproduced in Alaska. Similarly, an analysis of Aleut middens by Yesner (1976) failed to find fledgling remains from over 400 samples.

As stated above, breeding colonies of the short-tailed albatross are currently known on two islands in the western North Pacific and East China Sea. The marine range within U.S. territorial waters includes Alaska's coastal shelf break areas and the marine waters of Hawaii for foraging. The extent to which the birds use open ocean areas of the Gulf of Alaska, North Pacific Ocean, and Bering Sea is unknown (65 FR 46643). Short-tailed albatross frequent nearshore and coastal waters, with "many" birds being sighted within 10 km (6 mi) of shore, and fewer birds ("several") observed within 5 km (3 mi) of shore (65 FR 46643). However, the short-tailed albatross sighting dataset (1903-2003) shows no sightings within Cook Inlet and only one in Shelikof Strait (Drew 2005)); the proposed permit area is therefore not part of the typical range of this species (MMS 2003).

5.5.4.2 Critical Habitat

No critical habitat has been designated for short-tailed albatross. The USFWS has determined that the designation of critical habitat for this species is not prudent because it would "not be beneficial to the species" (65 FR 46643). USFWS concluded that designation of critical habitat for potential and actual breeding areas within United States' areas of jurisdiction on the Midway Atoll National Wildlife Refuge would be not provide additional benefit or protection over that conferred through the jeopardy standard of Section 7 of the ESA. With regard to the designation of critical habitat for foraging in the waters of United States, USFWS concluded there is no information available to support a conclusion that any specific marine habitat areas are uniquely important (65 FR 46643).

5.5.4.3 Life History

Short-tailed albatross are long-lived and slow to mature, with an average age at first breeding of 6 years old (USFWS 2009). Breeding is limited to the two Japanese Islands of Torishima and Minami-kojima, with birds arriving in October. Breeding and egg-laying are initiated throughout the month and is continued into late November. The chicks hatch in late December and January and are close to being full grown by late May or early June, at which time the adults begin to abandon the breeding colony and return to sea. The chicks fledge after the departure of the breeding adults and leave the colony by mid-July. Non-breeders and failed breeders disperse from the breeding colony in late winter through spring (USFWS 2009). The specific geographical and seasonal distribution patterns of the birds following departure from the breeding colonies has not been well understood until recently. Telemetry studies conducted by Suryan et al. (2007) found that the birds ranged widely throughout the North Pacific Rim, spending time within the exclusive economic zones of Japan, Russia (Kuril Islands and Kamchatka Peninsula), and the United States (Aleutian Islands and Bering Sea, Alaska). However, albatrosses spent the greatest proportion of time off the coast of Alaska, overlapping fisheries along the continental shelf break and slope regions.

5.5.4.4 Population Trends and Risks

The total population of short-tailed albatross in 2008-2009 is estimated to be 2,572 birds (USFWS 2009), over twice the number in 2000 (1,200 birds). Demographic information indicates that the breeding population on the island of Torishima is growing at an annual rate between 6.5 and 8.0 percent (H. Hasegawa, Toho Univ. pers. comm. in USFWS 2009). No information is available for the other breeding colony on the island of Minami-kojima.

The short-tailed albatross population is considered to be at risk due to the following factors (65 FR 46643, USFWS 2000a):

- The primary breeding colony on Torishima Island is at risk due to the potential for habitat destruction from volcanic eruptions on the island and the destruction of nesting habitat and birds by frequent mud slides and erosion caused by monsoon rains.
- Direct harvest of birds at the breeding colonies in Japan at the beginning of the 20th century dramatically reduced the numbers of birds. Harvesting continued until the early 1930s. By 1949, there were no short-tailed albatross breeding at any of the historically known breeding sites, and the species was thought to be extinct.
- The world population is vulnerable to the effects of disease because of the small population size and extremely limited number of breeding sites.
- Oil spills are considered to pose a potential threat to the species' conservation and recovery due to damage related to oil contamination, which could cause physiological problems from petroleum

toxicity and by interfering with the bird's ability to thermoregulate. An oil spill in an area where a large number of birds were rafting, such as near breeding colonies, could significantly affect the population.

- Consumption of plastics at sea may be a factor affecting the species' conservation and recovery. Plastics can cause injury or mortality due to internal damage following ingestion, reduction in ingestion volumes, or dehydration.
- Mortality incidental to longline fishing in the North Pacific and Bering Sea. ESA consultations have determined that Alaskan groundfish and halibut fisheries are likely to adversely affect short-tailed albatrosses, but are not likely to result in an appreciable reduction in the likelihood of survival and recovery of the species.

5.5.5 STELLER'S EIDER (Polysticta stelleri)

The Alaskan breeding populations of Steller's eider were listed as threatened under the ESA on June 11, 1997 (62 FR 31748). Two breeding populations in Arctic Russia are not part of the ESA listing in the U.S. and are not addressed in this section.

5.5.5.1 Geographic Range and Distribution

The historical breeding range of the Alaska-breeding population of Steller's eider is unclear; it may have extended discontinuously from the eastern Aleutian Islands to the western and northern Alaska coasts, possibly as far east as the Canadian border (USFWS 2001). In western Alaska, historical (pre-1970) data suggests that the birds formerly nested on the Yukon-Kuskokwim River Delta (Y-K Delta) and at least occasionally at other western Alaska sites, including the Seward Peninsula, St. Lawrence Island, and possibly the eastern Aleutian Islands and Alaska Peninsula (Quakenbush and Cochrane 1993, Flint and Herzog 1999, USFWS 2002). They spend the late fall and winter in shallow bays, feeding on mollusks and crustaceans. In the spring, Steller's eiders remain concentrated in these bays to await the retreat of sea ice and opening of overwater migratory routes to their breeding areas in northern Alaska. Eiders may be present in Cook Inlet between October and April, and are frequently found in shallow nearshore marine waters along the Kenai Peninsula between Homer and Clam Gulch, and in Kachemak Bay, Iniskin Bay, Iliamna Bay, and Kamishak Bay (Larned 2006).

In recent times, breeding is known to occur in two general areas, beyond the boundaries of the proposed Cook Inlet Exploration general permits. These areas comprise the Arctic Coastal Plain on the Alaskan North Slope and, to a lesser extent, on the Y-K Delta in western Alaska (USFWS 2001). The Arctic Coastal Plain, particularly the area surrounding Barrow, is extremely important to nesting Steller's eiders (USFWS 2002). Aerial surveys conducted from 1999 to 2002 in a 2,757 km^2 (1064.5 mi^2) area from Barrow south to Meade River recorded between two to over 100 breeding pairs for a maximum density of 0.08 birds per km^2 (2.1 birds/mi^2). In contrast, only seven nests were found on the Y-K Delta from 1994 to 2002 (USFWS 2002).

After breeding, Steller's eiders move to marine waters where they molt and individuals remain flightless for about 3 weeks. The birds, which presumably consist of members of both Alaskan and Russian populations, primarily molt outside of the proposed Cook Inlet Exploration general permit areas along the north side of the Alaska Peninsula, in Izembek Lagoon, Nelson Lagoon, Port Heiden, and Seal Islands

(USFWS 2002). After molting, many Steller's eiders disperse to the Aleutian Islands, the south side of the Alaska Peninsula, Kodiak Island, and as far east as Cook Inlet. Wintering birds usually occur in waters less than 10 m (30 ft) deep and are, therefore, usually found within 400 m (1312 ft) of shore except where shallows extend further offshore in bays and lagoons (USFWS 2002).

The winter range from the Kodiak Island east to lower Cook Inlet overlaps the geographical area of the proposed Cook Inlet Exploration general permits. Birds from Alaskan and Russian breeding populations intermix on the wintering grounds; however, unclear what percent of the wintering birds comprise the ESA-listed population (Alaskan breeding population). According to the USFWS, about 4.2 percent of the Steller's eider in or near the Cook Inlet area are assumed to be from the Alaskan breeding population (MMS 2003).

5.5.5.2 Critical Habitat

Designated critical habitat for the Steller's eider includes five units located along the Bering Sea and north side of the Alaskan Peninsula. These areas are the Delta, Kuskokwim Shoals, Seal Islands, Nelson Lagoon, and Izembek Lagoon (USFWS 2001). Within these areas, the primary habitat components that are essential include areas to fulfill the biological needs of feeding, roosting, molting, and wintering. Important habitats include the vegetated intertidal zone and marine waters up to 9 m (30 ft) and the underlying substrate and benthic community, associated invertebrate fauna, and, where present, eelgrass beds and associated biota (USFWS 2001).

No critical habitat is designated within the geographical area of the proposed Cook Inlet Exploration general permits for oil and gas exploration, development, and production facilities in Cook Inlet, Alaska.

5.5.5.3 Life History

Steller's eiders exhibit strong fidelity to wintering (Jones 1965) and molting (Dau et al. 1985, Flint et al. 2000) areas. Courtship begins in late winter and most pair formation occurs prior to dispersal toward breeding grounds (McKinney 1965). Wintering aggregations on the Alaska Peninsula begin migrations in mid- to late-April, with large numbers departing from Izembek in a matter of days (McKinney 1965, Laubhan and Metzner 1999). Steller's eider nest on tundra adjacent to small ponds or drained basins in locations generally near the coast, but ranging at least as far as 90 km (56 mi) inland (USFWS 2002). Young hatch in late June and feed in wetland habitat on aquatic insects and plants until they are capable of flight in about 40 days. After breeding, Steller's eiders move to marine waters of southwest Alaska, including Cook Inlet, where they molt from late July to late October (Petersen 1980, Laubhan and Metzner 1999). After molting most birds disperse to winter in shallow, sheltered waters along the south side of the Alaska Peninsula, Kodiak island, and as far east as Cook Inlet (USFWS 2002). The number of Steller’s eiders in Cook Inlet increases through early winter, peaking in January and February before the spring migration to nesting grounds occurs (Larned 2006). While in marine waters, Steller's eider forage primarily on mollusks and crustaceans.

5.5.5.4 Population Trends and Risks

Evidence suggests that the breeding range of Steller’s eiders in Alaska has substantially contracted, with the species disappearing from much of its historical range in western Alaska (Dau et al. 2000). The size of the breeding population on the Alaskan North Slope shows considerably variation among years, and it is not known whether the population is currently declining, stable, or improving (65 FR 13262). Determining population trends for Steller's eider is difficult due to the inherent problems of conducting aerial bird counts and the lack of a species-specific correction factor to apply to the resulting data (65 FR 13262). However, counts conducted in 1992 indicate that at least 138,000 birds winter in southwest Alaska; although the proportion belonging to the Alaska-breeding population versus those from Russian-breeding populations is uncertain (USFWS 2002). More specifically, Larned (2006) estimated winter populations of 1,247 and 4,284 eiders in the eastern and western portions of Cook Inlet, respectively. High abundances were found along nearshore areas of the eastern portion of Cook Inlet from Anchor Point to 25 km (15.5 mi) north of Ninilchik and from Homer Spit to Anchor Point. To the west, important areas include southern Kamishak Bay from Douglas River to Bruin Bay, including the shoreline between Bruin Bay and Ursus Cove, and a shoal 12 km (7.5 mi) southeast of Bruin Bay and the mouth of Iniskin Bay.

The Alaska-breeding population of the Steller's eider is considered to be at risk. The destruction or modification of habitat is not thought to have contributed to the decline of the species; however, numerous factors are detailed in USFWS (2002), including:

- Exposure to lead through ingestion of spent lead shot when foraging may pose a significant health risk to Steller's eiders.
- Although there is no information to suggest that disease contributed to the decline of Steller's eiders, recent sampling suggests that Steller's eiders and other sea ducks in Alaska may have significant exposure rates to a virus in the family Adenoviridae.
- Changes in predation pressure in breeding areas are hypothesized as the reason for the near disappearance of birds on the Y-K Delta. Recent studies within the primary breeding area on the North Slope near Barrow suggest that nest success is very poor and predation is thought to be the primary factor.
- Although hunting of Steller's eider is prohibited under the Migratory Bird Treaty Act, some intentional or unintentional shooting occurs.

5.5.6 BLUE WHALE (Balaenoptera musculus)

The blue whale was listed as endangered under the ESA on June 2, 1970 (35 FR 8495).

5.5.6.1 Geographic Boundaries and Spatial Distribution

Blue whales are found in all of the world's oceans from the Arctic to the Antarctic. In the North Pacific, they rarely enter the Bering Sea and are only seldom seen as far north as the Chukchi Sea (Yochem and Leatherwood 1985, Rice 1986, ADF&G 1994a). In the eastern North Pacific, they winter off southern and Baja California; during the spring and summer they are found from central California northward through the Gulf of Alaska. Historical areas of concentration in Alaska include the eastern Gulf of Alaska and the eastern and far western Aleutians (ADF&G 1994a).

Blue whales are believed to migrate away from coastlines and feed preferentially in deeper offshore waters (Mizroch et al. 1984, Gregr and Trites 2001). They are seldom seen in nearshore Alaska waters

(ADF&G 1994a. These preferences make it highly unlikely that blue whales would frequent Cook Inlet waters within the area of coverage of the proposed Cook Inlet Exploration general permits.

5.5.6.2 Critical Habitat

No critical habitat has been designated for the blue whale.

5.5.6.3 Life History

Blue whales are estimated to reach sexual maturity between 5 and 15 years of age, and may live as long as 70 to 80 years (Mizroch et al. 1984, Yochem and Leatherwood 1985, Environment Canada 2004b). Reproduction generally occurs during the winter months. Females bear a single calf, following a gestation period of 10 to 12 months and nursing continues approximately 6 to 7 months following birth (ADF&G 1994a, NMFS 1998). Weaning is thought to occur as the whales move from low-latitude wintering areas to high-latitude summer feeding grounds (NMFS 1998).

Blue whales appear to practice more selective behavior in feeding than other rorquals (those baleen whales that possess external throat grooves that expand during gulp-feeding) and specialize in plankton feeding, particularly swarming euphausiids (krill) in the Antarctic. In the North Pacific, the species *Euphausia pacifica* and *Thysanoessa spinifera* are the main foods of blue whales (Rice 1986, ADF&G 1994a); however, more recent studies suggest blue whales feed primarily on the latter (Schoenherr 1991, Kieckhefer et al. 1995, Fiedler et al. 1998).

5.5.6.4 Population Trends and Risks

Historical abundance of blue whales prior to commercial harvesting operations is estimated to have been between 4,900 and 6,000 (ADF&G 1994a). Following protection status imposed in 1966 by the International Whaling Commission (IWC), it was anticipated that whale stocks would begin to recover but there is no evidence to support that contention (NMFS 1998). In a recent study using photographic mark-recapture techniques, Calambokidis et al. (2010) estimates the current North Pacific population at 2,497 individuals. However, few sightings of blue whales have been reported in Alaskan waters. The first confirmed occurrence in 30 years was documented by NOAA scientists on July 15, 2004, 100 nautical miles southeast of Prince William Sound (Joling 2004).

The North Pacific blue whale is considered to be at risk due to the following factors:

- Commercial whaling harvested 9,500 blue whales from the North Pacific between 1910 and 1965 (Ohsumi and Wada 1974). Commercial whaling has been prohibited in the United States since 1972 and there has been an International Whaling Commission prohibition on taking blue whales since 1966 (NMFS 1998).
- Ship strikes have been implicated in the deaths of blue whales in the eastern North Pacific in 1980, 1986, 1987, and 1993. Additional mortality from ship strikes that are unreported is likely (NMFS 1998).
- The offshore drift gillnet fishery is the only fishery likely to take blue whales in the eastern North Pacific. Approximately 2,000 whales were taken off the west coast of North America between 1910 and 1965 (NMFS 1998).

- Habitat loss due to sound derived from anthropogenic sources (Reeves et al. 1998)

5.5.7 FIN WHALE (Balaenoptera physalus)

Fin whales were first listed on June 2, 1970 under the Endangered Species Conservation Act of 1969 (35 FR 8491) and are currently designated as endangered in their entire range under the Endangered Species Act of 1973 and "depleted" under the MMPA. Three stocks of fin whales are currently recognized in U.S. Waters including Alaska (Northeast Pacific), California/Washington/Oregon, and Hawaii. However, new data from Mizroch et al. (2009) suggest the existence of 2 migratory stocks (eastern and western Pacific) and 2 to 4 stocks that occur in peripheral seas, including the Gulf of California, East China Sea, Sanriku-Hokkaido and possibly in the Sea of Japan. These findings should be further evaluated to determine if a change in the management of currently recognized stocks is warranted (NMFS 2010a).

5.5.7.1 Geographic Boundaries and Distribution

In the North Pacific Ocean, fin whales can be found from above the Arctic Circle to lower latitudes of approximately 20°N (Leatherwood et al. 1982). Rice (1974) reported summer distributions along nearshore areas from central Baja California to Japan, and extending north as far as Chukchi Sea.

Fin whales are believed to feed preferentially along offshore waters, with preferred habitat encompassing a large area that includes the continental shelf break and offshore waters (Gregr and Trites 2001). They are rarely seen in inshore coastal waters. Fin whales regularly inhabit areas near NPDES permit coverage, including Shelikof Strait, bays along Kodiak Island (especially Uganik and Uyak bays on the west side), and the Gulf of Alaska. Some or all of these areas are known feeding areas. Sighting data suggest that the distribution and abundance of fin whales in these areas vary seasonally, but there is documented use in the vicinity of Kodiak Island every month of the year except December and January (MMS 2003).

5.5.7.2 Critical Habitat

No critical habitat has been designated for the fin whale.

5.5.7.3 Life History

Fin whales tend to be more social than other rorquals, gathering in pods of 2 to 7 whales or more. Reproductive activity generally occurs in winter following migration to warmer waters. Sexual maturity occurs at the ages of 6 to 10 years in males and 7 to 12 years in females, and species may live as long as 90 years (OBIS 2005). Ohsumi (1986) found that the species exhibits a dramatic response to exploitation pressures. Data from the mid-1950s to 1975 indicate a decline in the average age of sexual maturity from 12 to 6 years in females and from 11 to 4 years in males. Ohsumi concluded the decline to be a density dependent response to intense harvesting of the population.

Fin whales feed on a variety of euphausiids (*Euphausia pacifica*, *Thysanoessa longipes*, *T. pinifera*, and *T. inermis*) and large copepods, primarily *Calanus cristatus* (Nemoto 1970, Kawamura 1982). The species is also known forage on schooling fish, such as herring, walleye pollock, and capelin (OBIS 2005).

5.5.7.4 Population Trends and Risks

For the entire North Pacific population, abundance estimates range from 42,000 to 45,000 individuals prior to commercial exploitation, and from 14,620 to 18,630 individuals in the early 1970s (Ohsumi and Wada 1974). In Alaska, surveys conducted in 1994 covering 2,050 nautical miles of track line south of the Aleutian Islands encountered only four fin whale groups. Results of surveys in the central-eastern Bering Sea and southeastern Bering Sea conducted in 1999 and 2000 provided estimates of 3,368 and 683, respectively, although these are conservative, uncorrected estimates (i.e., no adjustments made for whales missed during the survey, etc., Moore et al. 2002). Additional sighting cruises were conducted in coastal waters of western Alaska and the eastern and central Aleutian Islands in July-August 2001-2003 between the Kenai Peninsula (150°W) and Amchitka Pass (178°W) that detected 1,652 whales (Zerbini et al. (2006). Together these survey results combine for a minimum population estimate of 5,703 whales.

The risk of human-related mortality is relatively low for fin whales. Prior to 1999, no injuries or mortality associated with commercial fishing had been reported for the North Pacific Stock. In 1999, one mortality associated with the Gulf of Alaska pollock trawl fishery occurred. Ship strikes appear infrequent with one strike in Uyak Bay reported between 1997 and 2001. Fin whales in the Alaska stock are not harvested for subsistence and no habitat-related limiting factors have been identified for this species (Angliss and Outlaw 2005).

5.5.8 HUMPBACK WHALE (*Megaptera novaeangliae*)

Humpback whales were listed as endangered throughout their range on June 2, 1970 under the ESA (35 FR 8491) and are considered "depleted" under the MMPA.

5.5.8.1 Geographic Boundaries and Distribution

The humpback whale is distributed worldwide in all ocean basins, although it is less common in Arctic waters. Currently there are four recognized stocks of humpback whales in U.S. waters based on geographically distinct winter ranges (NMFS 2011a): Gulf of Maine stock, eastern North Pacific stock, central North Pacific stock, and the western North Pacific stock. The central and western North Pacific stocks inhabit Alaskan waters. In Alaskan waters, most humpbacks tend to concentrate in southeast Alaska, Prince William Sound, the area near Kodiak and Barren Islands, the area between the Semidi and Shumagin Islands, eastern Aleutian Islands, and the southern Bering Sea (ADF&G 1994b). In inside waters off southeastern Alaska (i.e., Glacier Bay and Frederick Sound) photo-identification studies summarized by Perry et al. (1999) appear to show that humpback whales use discrete, geographically isolated feeding areas that individual whales return to year after year. These studies find little documented exchange in individual animals between Prince William Sound areas and the Kodiak Island area and between the Kodiak Island area and southeast Alaska feeding areas, suggesting that while movement among these areas may occur, it is reasonably uncommon.

Although humpback whales can be observed year-round in Alaska, most animals migrate during the fall to temperate or tropical wintering areas where they breed and calve. Most whales that spend the summer in Alaskan waters are thought to migrate to overwinter in waters near Hawaii (ADF&G 1994b, Perry et al. 1999). Feeding occurs preferentially over continental shelf waters (Gregr and Trites 2001) and is often observed relatively close to shore, including major coastal embayments and channels (NMFS 2011a). In the summer, humpback whales are regularly present and feeding in areas near and within the Cook Inlet lease-sale area, including Shelikof Strait, bays of Kodiak Island, and the Barren Islands, in addition to the Gulf of Alaska adjacent to the southeast side of Kodiak Island (especially Albatross Banks), the south sides of the Kenai and Alaska peninsulas, and south of the Aleutian Islands. There is some evidence of a discrete feeding aggregation of humpbacks in the Kodiak Island region. Humpbacks also may be present in some of these areas throughout the autumn. Within the proposed lease-sale area, large numbers of humpbacks have been observed in late spring and early summer feeding near the Barren Islands. Humpbacks have also been observed feeding near the Kenai Peninsula north and east of Elizabeth Island (MMS 2003).

5.5.8.2 Critical Habitat

No critical habitat has been designated for the humpback whale anywhere throughout their range.

5.5.8.3 Life History

Humpback whales are seasonal migrants. The whales mate and give birth while in wintering areas outside of Alaskan waters. Sexual maturity occurs between the ages of 4 and 6 years, with mature females giving birth every 2 to 3 years (ADF&G 1994b). During spring, the whales migrate back to feeding areas in Alaskan waters, where they spend the summer (ADF&G 1994b, Perry et al. 1999).

Humpback whales use a variety of feeding behaviors to capture food, including underwater exhalation of columns of bubbles that concentrate prey, feeding in formation, herding of prey, and lunge feeding (ADF&G 1994b). Based on their diet, humpbacks have been classified as generalists (Perry et al. 1999). They have been known to prey upon euphausiids (krill), copepods, juvenile salmonids (*Oncorhynchus* spp.), Arctic cod (Boreogadus saida), capelin (*Mallotus villosus*), Pacific herring (*Clupea harengus pallas*i), sand lance (*Ammodytes hexapterus*), walleye pollock (*Theragra chalcogramma*), pollock (*Pollachius vixens*), pteropods, and some cephalopods. On Alaska feeding grounds, humpback whales feed primarily on capelin, juvenile walleye pollock, sand lance, Pacific herring, and krill (Perry et al. 1999).

5.5.8.4 Population Trends and Risks

The population of humpback whales living in the North Pacific is estimated at 20,800-21,808 individuals (NMFS 2010b). Summer feeding areas of Alaska were surveyed by different researchers, and observations include 315 humpback whales in Prince William Sound, 615 in the Kodiak region, 410 in the Shumagin Islands, 1,175 in the central-eastern Bering Sea, 102 in the eastern Bering Sea, and 2,644 on the coastal shelf waters in the Gulf of Alaska/Aleutian Islands. The recent SPLASH survey observed "63 humpback whales in the Aleutian Islands, 491 in the Bering Sea, 301 in the western Gulf of Alaska (including the Shumagin Islands), and 1,038 in the northern Gulf of Alaska (including Kodiak and Prince William Sound) (NMFS 2010b). A total of 6,000-19,000 whales were estimated for the waters near Alaska. Population trends show that North Pacific humpback populations may be increasing by 5-10% per year (NMFS 2010b).

Historic and current risk factors influence the population and well-being of humpback whales. Commercial whaling harvested more than 28,000 animals from the North Pacific during the 20th century and may have reduced this population to as few as 1,000 individuals after the 1965 hunting season (NMFS 2011a). Presently, commercial fisheries may pose a risk to humpback whales. Between 2002 and 2006, at least three mortalities or serious injuries were reported. The rate of mortality or serious injury related to commercial fishing in Alaska (including entanglement and ship strikes) was 3.8 humpback whales per year between 2003 and 2007. Ship strikes pose a risk to humpback whales with 7 collisions occurring in Southeast Alaska between 2003 and 2007 (NMFS 2010b).

Anthropogenic sources of noise are another source of risk to whale populations. Humpbacks exhibit variable responses to noise, and the level and type of response exhibited by whales has been correlated to group size, composition, and apparent behaviors at the time of possible disturbance. Humpback whales have suffered severe mechanical damage to their ears from noise pulses from underwater blasting; whales exposed to playbacks of noise from drillships, semisubmersibles, drilling platforms, and production platforms do not exhibit avoidance behaviors at noise levels up to 116 db (Malme et al. 1985). Other potential risks to humpback whales include habitat degradation, exposure to contaminants, and resource competition (NMFS 1991).

5.5.9 NORTH PACIFIC RIGHT WHALE *(Eubalaena japonica)*

The Northern Right whale (Balaena glacialis) was listed as endangered under the ESA on June 2, 1970 (35 FR 8495). On April 10, 2003, the NMFS published a final rule that split the endangered northern right whale into two endangered species: North Atlantic right whale (*Eubalaena glacialis*) and North Pacific right whale (*Eubalaena japonica*) (68 FR 17560). On March 6, 2008 the North Pacific right whale was listed as a separate endangered species (73 FR 12024).

5.5.9.1 Geographic Boundaries and Distribution

The North Pacific stock of northern right whale has historically occurred across the North Pacific, north of 35°N latitude, with concentrations of whales occurring in the Gulf of Alaska, eastern Aleutian Islands, south-central Bering Sea, Sea of Okhotsk, and the Sea of Japan (66 FR 17560).

Two populations of North Pacific right whale are thought to exist, one in the western North Pacific off Russia and the other in the eastern North Pacific off Alaska (MMC 2002). The distribution and status of neither population is well understood. The eastern population is more severely depleted than western population, with the population thought to number in the tens of individuals versus hundreds for the western population (MMC 2002, NMFS 2011b). Between 1900 and 1994, there have been only 29 reliable sightings of right whales in the eastern North Pacific. Since that time between 4 and 13 individuals have been sighted each year; all these sightings have occurred in an area approximately 200 nautical miles north of Unimak Pass in the southeastern Bering Sea (CBD 2000, MMC 2002, NMFS 2002a).

Because the North Pacific eastern population is so small and infrequently sighted, little is known about their range and movements. The whales are thought to move northward to high latitudes in the spring, summer in the Bering Sea and Gulf of Alaska, and move southward in the fall and winter possibly as far south as Baja, California (CBD 2000,NMFS 2002a).

Historically, right whales often were observed in coastal waters where their slow speed and tendency to float after death resulted in their near-decimation by whalers in the 1800s. Recent whale sightings have all occurred within the shallower waters of the continental shelf (CBD 2000). No information currently exists regarding the presence of this species in Cook Inlet, Alaska.

5.5.9.2 Critical Habitat

On June 3, 1994, the NMFS designated critical habitat for the species of northern right whale (59 FR 28793), which as of April 10, 2003, became referred to as the North Atlantic right whale (68 FR 17560). The three areas designated as critical habitat are in the North Atlantic Ocean off the eastern United States. NMFS determined at that time that insufficient information was available to consider critical habitat designation for other stocks of northern right whale, including whales residing in the North Pacific.

On October 4, 2000, the Center for Biological Diversity petitioned the NMFS to designate a portion of the southeastern Bering Sea as critical habitat for the North Pacific right whale on the basis of annual sightings of whales in the area that suggests the area is a summer feeding ground for this severely depleted population (CBD 2000). On July 11, 2001, the Marine Mammal Commission responded to this request by recommending that NMFS proceed with designating the area as critical habitat and modify the boundaries as future data on population distribution becomes available (MMC 2002). However, on February 20, 2002, NMFS published notice that the Service had determined that the petitioned action to designate critical habitat was not warranted at this time (67 FR 7660) noting that because the essential biological requirements of the population in the North Pacific Ocean are not sufficiently understood, the extent of critical habitat cannot be determined. Currently, no critical habitat has been designated for the North Pacific right whale.

5.5.9.3 Life History

As noted in Section 3.9.1, little is known about the movements of the eastern population of North Pacific right whale; although some authors believe they may move seasonally from areas in the Bering Sea and Gulf of Alaska southward possibly as far as the waters off Baja, California (CBD 2000, NMFS 2002a). No sightings of a cow with a calf have been confirmed since 1900 (67 FR 7660).

Among baleen whales, right whales appear to have the most specialized feeding strategy. Studies conducted in the North Atlantic suggest that right whales require high densities of copepods concentrated in surface waters for effective feeding; the feeding requirements of an adult whale are estimated to be at least 4.07×10^5 Kcal/day (CBD 2000). The feeding preferences of North Pacific right whales have not been determined; however, the NMFS has noted that these whales probably feed almost exclusively on calanoid copepods, a component of the zooplankton (67 FR 7660).

5.5.9.4 *Population Trends and Risks*

The pre-exploitation size of the population on North Pacific right whales has been estimated as likely exceeding 10,000 animals (67 FR 7660, February 20. 2002) to 19,000 animals (CBD 2000). The current population is thought to be very small, perhaps in the tens of animals (67 FR 7660) to low hundreds (NMFS 2005a). Periodic sightings and aerial and vessel survey efforts conducted by NMFS in the Bering Sea and Gulf of Alaska between 1997 and 2000 indicated that at least small groups of right whales were using offshore waters in Bristol Bay (1996, 3-4 individuals; 1997, two sighting of 4-5 individuals including a juvenile; 2002, 7 individuals plus one calf), and elsewhere in the southeastern and central Bering Sea (1998, 6 individuals; 1999, 5 individuals and 2 individuals; 2000, 8 individuals; ([69 FR 30857]). In 2004, researchers radio tagged two right whales in the Bering Sea and subsequent radio tracking efforts in September 2004 revealed a concentration of 25 North Pacific right whales among the Aleutian Islands feeding in shallow waters near humpback and fin whales. This observation was particularly noteworthy because of the size of the group, and because the group included three cow/calf pairs. Currently, no reliable estimates of abundance or population trends exist for the North Pacific stock.

Historic and current risk factors influence the population and well-being of right whales. Whaling records indicate that during the 19th century, pelagic whalers harvested over 15,000 North Pacific right whales. As early as the 1870s, the whale was noted as being rare (CBD 2000). It is difficult to assess risk to Northern Pacific right whale populations since so few animals are observed. Currently, it is expected that commercial fishing activities pose a risk to right whales, however the magnitude and nature of entanglements in fishing gear are not known. Approximately 57-62 percent of right whales in the North Atlantic bear scars and injuries indicative of fishing gear entanglement (NMFS 2005a). The extent of fisheries in the southeastern Bering Sea suggests that fishing gear entanglements may also pose a risk to North Pacific right whale.

Right whales are slow-swimming and spend much of their time near the surface of the water, which makes them susceptible to ship strikes. While ship strikes are a significant source of mortality to right whales in the North Atlantic Ocean, it is unknown how often collisions occur in the North Pacific (Right Whale Listening Network, undated). Disturbance due to anthropogenic noise may affect right whales by changing normal behavior to temporarily or permanently avoid noise sources. Anthropogenically produced sounds may also raise background noise levels and mask the detection of sounds from other whales or natural sources. Information on the hearing capacity of right whales is not available; however, some authors have suggested that their hearing abilities are especially acute below 1 kHz (CBD 2000). Other potential risks to the North Pacific right whale include habitat degradation, contaminants, military activities, and climate and ecosystem change.

5.5.10 SEI WHALE (Balaenoptera borealis)

The sei whale was listed as endangered under the ESA on June 2, 1970 (35 FR 8498). As such, the eastern North Pacific stock is considered as a "depleted" and "strategic" stock under the MMPA.

5.5.10.1 Geographic Boundaries and Distribution

Sei whales have historically occurred in all oceans of the world, migrating from low-latitude wintering areas to high-latitude summer feeding grounds (Fisheries and Oceans Canada 2005). In the eastern North Pacific, sei whales are common in the southwest Bering Sea to the Gulf of Alaska, and offshore in a broad arc between about 40°N and 55°N (Environment Canada 2004a, WWF 2005).

The sei whale prefers deeper offshore waters, with preferred habitat tending to occur in offshore areas that encompass the continental shelf break (Gregr and Trites 2001). Commercial whaling catch records off British Columbia indicate that less than 0.5 percent of sei whales were caught in waters over the continental shelf (Environment Canada 2004a). These preferences make it unlikely that sei whales would frequent Cook Inlet waters within the geographic area covered by the proposed Cook Inlet Exploration general permits.

5.5.10.2 Critical Habitat

No critical habitat has been designated for the sei whale.

5.5.10.3 Life History

Sei whales reach sexual maturity between 5 and 15 years of age, and may live as long as 60 years. Like many other species of baleen whales, sei whales migrate from low-latitude wintering areas to high-latitude summer feeding grounds. Catch records suggest that whale migrations are segregated according to length (age), sex, and reproductive status. Pregnant females appear to lead the migration to feeding grounds, while the youngest animals arrive last and depart first (Environment Canada 2004a). Sei whales feed primarily on copepods, followed by small squid, euphausiids, and small pelagic fish (Trites and Heise 2005).

5.5.10.4 Population Trends and Risks

The pre-whaling abundance of sei whales in the North Pacific has been estimated to range from 42,000- 62,000 animals (Ohsumi and Wada 1974, Tillman 1977). There are no current data on trends in sei whale abundance in the eastern North Pacific waters. A fact sheet prepared by NMFS (2000b) on the eastern North Pacific stock of sei whale suggest that the population is expected to have grown since being given protected status under the MMPA in 1976; however, continued unauthorized take, incidental ship strikes, and gill net mortality makes this uncertain.

Historic and current risk factors influence the population and well-being of sperm whales. Commercial whaling activities took 61,500 whales in the North Pacific between 1947 and 1987. The practice of commercial whaling has been prohibited in the United States since 1972 and the International Whaling Commission has prohibited harvesting sei whales since 1976 (ADF&G undated). Risk to anthropogenic noise (i.e. underwater communication, navigation, ships, oil and gas exploration/ development, military activity, and research) is unknown, but could cause hearing or tissue damage, altered behavioral responses, or mask biologically important communication signals in sei whales(NMFS 2011c). Ship collision risks are unknown but expected to be low risk to sei whales. Of 300 reported collisions reported between 1975 and 2002, only a few sei whale strikes were reported, none of which occurred in North Pacific waters. However, one strike was reported off the coast of Washington in the North Pacific between 2003 and 2008 (NMFS 2011c).

Whale harvesting, while mostly historic, has posed a significant risk on sei whale populations, and has resulted in the low populations currently observed. The IWC presently prohibits commercial whaling for sei wales, but Japan has maintained a scientific whaling program that harvested up to 100 whales per year between 1988 and 2009. A total of 592 sei whales were taken from the northwestern Pacific Ocean during that time period.

Loss of prey due to climate and ecosystem change poses an unknown but potentially high risk on sei whale populations. Increases in temperature may change availability of prey and affect whale migration, feeding patterns, and ability to use certain habitats for breeding or finding food. The risk of toxicity and bioaccumulation of contaminants and pollutants (e.g. PCBs, PAHs, DDT, DDE, dieldrin, mercury, other metals) is unknown, but it appears that concentrations of organochlorine and metal compounds are lower in baleen whale tissues than other kinds of marine mammals. Other factors that pose low or unknown risks to sei whales include oil spills, disease, injury from marine debris, research activities, predation, and resource competition (NMFS 2011c).

5.5.11 SPERM WHALE (Physeter macrocephalus)

The sperm whale was listed as endangered under the ESA on June 2, 1970 (35 FR 8495).

5.5.11.1 Geographic Boundaries and Distribution

Sperm whales inhabit all ocean basins, from equatorial to polar waters. Their distribution generally varies by gender and the age composition of groups, and is influenced by prey availability and oceanic conditions (Perry et al. 1999). In the North Pacific, sperm whales are distributed widely, with the northernmost boundary extending from Cape Navarin (62°N) to the Pribilof Islands (Angliss and Lodge 2003). Mature females, calves, and immature whales of both sexes in the North Pacific are found in social groups and remain in tropical and temperate waters year round from the equator to approximately 45°N latitude (Perry et al. 1999, Angliss and Lodges 2003). Males lead a mostly solitary life after reaching sexual maturity between 9 and 20 years of age and are thought to move north in the summer to feed in the Gulf of Alaska, Bering Sea, and waters around the Aleutian Islands. Research has revealed considerable east-west movement between Alaska and the western North Pacific (Japan and Bonin Islands), with little evidence of north-south movement in the eastern Pacific (Perry et al. 1999, Angliss and Lodge 2003).

The habitat preferred by sperm whales differs among the sexes and age composition of individual whales. The social groups comprised of females, calves, and immature whales have a broader habitat distribution than males; they are generally restricted to waters with surface temperatures greater than 15°C (59°F) and are rarely found in areas with water depths less than 200 to 1,000 m (656 to 3,280 ft) (Reeves and Whitehead 1997, Gregr and Trites 2001). Males exhibit a tighter distribution over deeper waters along the continental shelf break, and are often found near steep drop-offs or other oceanographic features (e.g., offshore banks, submarine trenches and canyons, continental shelf edge), presumably because these areas have higher foraging potential (Gregr and Trites 2001, AKNHP 2005).

The distribution of sperm whale indicates that male sperm whales are the only sex that frequent Alaskan waters. Available evidence indicates that males are present offshore in the Gulf of Alaska during the summer, but they are very unlikely to be present in the permit coverage area in Cook Inlet.

5.5.11.2 Critical Habitat

No critical habitat has been designated for the sperm whale.

5.5.11.3 Life History

Sperm whales appear to be organized in a social system that consists of groups of 10-40 adult females plus their calves which remain year-round in tropical and temperate waters. Solitary males join these groups during the breeding season, which takes place in the middle of the summer (NMML 2004a). Males reach sexual maturity at 9-20 years of age (Perry et al. 1999), but do not seem to take an actual part in breeding until their late 20s (ACS 2004). Female sperm whales reach sexual maturity at around 9 years of age and produce a calf approximately once every 5 years (NMFS 2012).

Sperm whales feed primarily on medium-sized deep water squid, with the remaining portion of their diet comprised of octopus, demersal and mesopelagic sharks, skates, and fish; feeding occurs all year round, usually at depths below 400 ft (ACS 2004, NMML 2004a, AKNHP 2005, NMFS 2012).

5.5.11.4 Population Trends and Risks

As of 2002, the world population of sperm whales was approximately 300,000 to 450,000, and the abundance in the Pacific was estimated to be 152,000 to 226,000. Using population estimates from models, it is expected that the world population is approximately 32% of historical numbers, and probably much lower in the Pacific where whaling was more prevalent than in other oceans (NMFS 2010d). Pre-whaling abundance estimates of sperm whale in the North Pacific are considered unreliable and range from 472,000 to 1,260,000 animals (Perry et al. 1999, Angliss and Lodge 2003). The abundance of whales in the North Pacific in the late 1970s was estimated to be 930,000 animals (Rice 1989). Approximately 102,112 sperm whales occur in the western North Pacific, but individual estimates for Alaska or other regions of the North Pacific are not available (NMFS 2010e).

Historic and current risk factors influence the population and well-being of sperm whales. Commercial whaling operations were responsible for harvesting 261,148 sperm whales between 1912 and 2006, with the vast majority (259,120) taken between 1946 and 1987 (NMFS 2010e). In addition to reducing overall numbers of animals, commercial whaling altered the male-to-female ratio by selective killing of the larger breeding age males (AKNHP 2005). Gear used in the modern fishing industry can pose an entanglement and trailing risk to marine mammals, with at least three serious injuries to sperm whales living in the Gulf of Alaska between 2002 and 2006 (NMFS 2010e). The average annual mortality rate based on observations from 1997 to 2001 is 0.4 whales per year. Most mortalities or injuries tend to occur with the longline fishery operating in the Gulf of Alaska waters east of Kodiak Island (AKNHP 2005).

Risk to anthropogenic noise (i.e., underwater communication, navigation, ships, military activity, and research) is unknown, but could cause hearing damage, altered behavioral responses, or mask biologically important signals including mating calls in sperm whales (NMFS 2010d). Ship collision risks are unknown but expected to be low risk to sperm whales. Sperm whales may be impacted by ship strikes, although their behavior suggest that they are at a lesser risk than other baleen whales that spend a greater proportion of their time in surface waters (NMFS 2011c). In a 2004 study, it was shown that of 292 recorded strikes, only 17 collisions occurred with sperm whales.

Other risks to sperm whales with low or unknown impacts include toxicity and bioaccumulation of contaminants and pollutants (e.g., PCBs, PAHs, DDT, DDE, dieldrin, mercury, other metals), oil spills, disease, injury from marine debris, research activities, predation, whale harvesting activities, and resource competition (NMFS 2010d).

5.5.12 BELUGA WHALE (*Delphinapterus leucas*)

Beluga whales are one of the two members of the family Monodontidae and are divided into five stocks on the basis of mitochondrial DNA analyses: Cook Inlet, Bristol Bay, eastern Bearing Sea, eastern Chukchi Sea, and Beaufort Sea (NMFS 2003). The most vulnerable of these populations is the Cook Inlet stock, which was determined to be depleted under the MMPA in 2000 (65 FR 34590). The Cook Inlet population is the most isolated spending the entire year in Cook Inlet (URS 2010). The Cook Inlet populations are known to spend the majority of the year in the northern portion of Cook Inlet. On October 22, 2008, NMFS listed the population as endangered under the ESA (73 FR 62919) and followed this action by designating critical habitat in Cook Inlet on April 11, 2011 (76 FR 20180).

5.5.12.1 Geographic Boundaries and Distribution

Beluga whales occur in arctic waters of the northern hemisphere, living in openings within the pack ice in winter and migrating to shallow bays and estuaries in summer. Beluga whales in U.S. waters range from Yakutat to the Beaufort Sea. Some beluga stocks migrate over thousands of miles for example, moving from the Bering Sea to the Mackenzie River estuary in Canada (ADF&G 1994e).

Movements during the summer and fall appear to be influenced by the timing and location of eulachon, salmon runs, and other anadromous fish species (NMFS 2005b; URS 2010) and tidal fluctuations (Funk et al. 2005). During the summer and fall beluga whales are concentrated near the Susitna River mouth, Knik Arm, Turnagain Arm, and Chickaloon Bay. During the winter, beluga whales concentrate in deeper waters in the mid-inlet to Kalgin Island although occasional sightings are reported in the upper inlet in Knik and Turnagain arms. Tagging data indicate that at least a portion of the Cook Inlet stock remains in the inlet throughout the year (NMFS 2005b). In spring, Cook Inlet beluga whales move toward the upper portions of the inlet where they occur in coastal areas, particularly near the mouths of rivers (Moore et al. 2000, NMFS 2005b) and along tidal flats. Large groups may remain in and near the Susitna River, Little Susitna River, Beluga River and the Turnagain Arm (Markowitz et al. 2005, Moore et al. 2000).

Beluga whales are known to move up rivers including those feeding Cook Inlet; individuals from northern stocks have been observed in the Yukon River as far upstream as Tanana, Rampart, and Fort Yukon (ADF&G 1994e).Moore et al. (2000) conclude that prey availability likely has the strongest influence on the distribution and relative abundance of belugas in Cook Inlet. The authors conclude that patterns and timing of eulachon and salmon runs seem to affect beluga feeding behavior. However, the impact on Cook Inlet belugas of a changing fish community could be difficult to quantify because the beluga diet is flexible and changes with season, location, sex, and age (Seaman et al. 1982; Stewart and Stewart 1989, as cited by Moore et al. 2000). To date, there has been no coordination between biologists counting fish runs (and thereby estimating the availability of some beluga prey) and those conducting surveys for belugas in Cook Inlet. Additional factors likely influencing beluga whale distribution include predation pressure, sea ice cover, and other environmental parameters, reproduction, sex and age class, and human activities (Rugh et al. 2000; Kingsley 2002).

5.5.12.2 Critical Habitat

Effective May 11, 2011, two areas comprising 7,800 km^2 (3,013 mi^2) were designated as critical habitat for beluga whales (76 FR 20180). Area 1 includes 1,909 km^2 (738 mi^2) of Cook Inlet northeast of a line from the mouth of Threemile Creek to Point Possession. The area provides important foraging and calving habitats, experiencing the greatest concentrations of belugas from spring through fall. Area 2 comprises 5,891 km^2 (2,275 mi^2) and is located to the south of Area 1. It includes nearshore areas along the west side of the Inlet and Kachemak Bay on the east side of the lower inlet. Critical habitat for beluga whales in Cook Inlet can be seen in Figure 2 below.

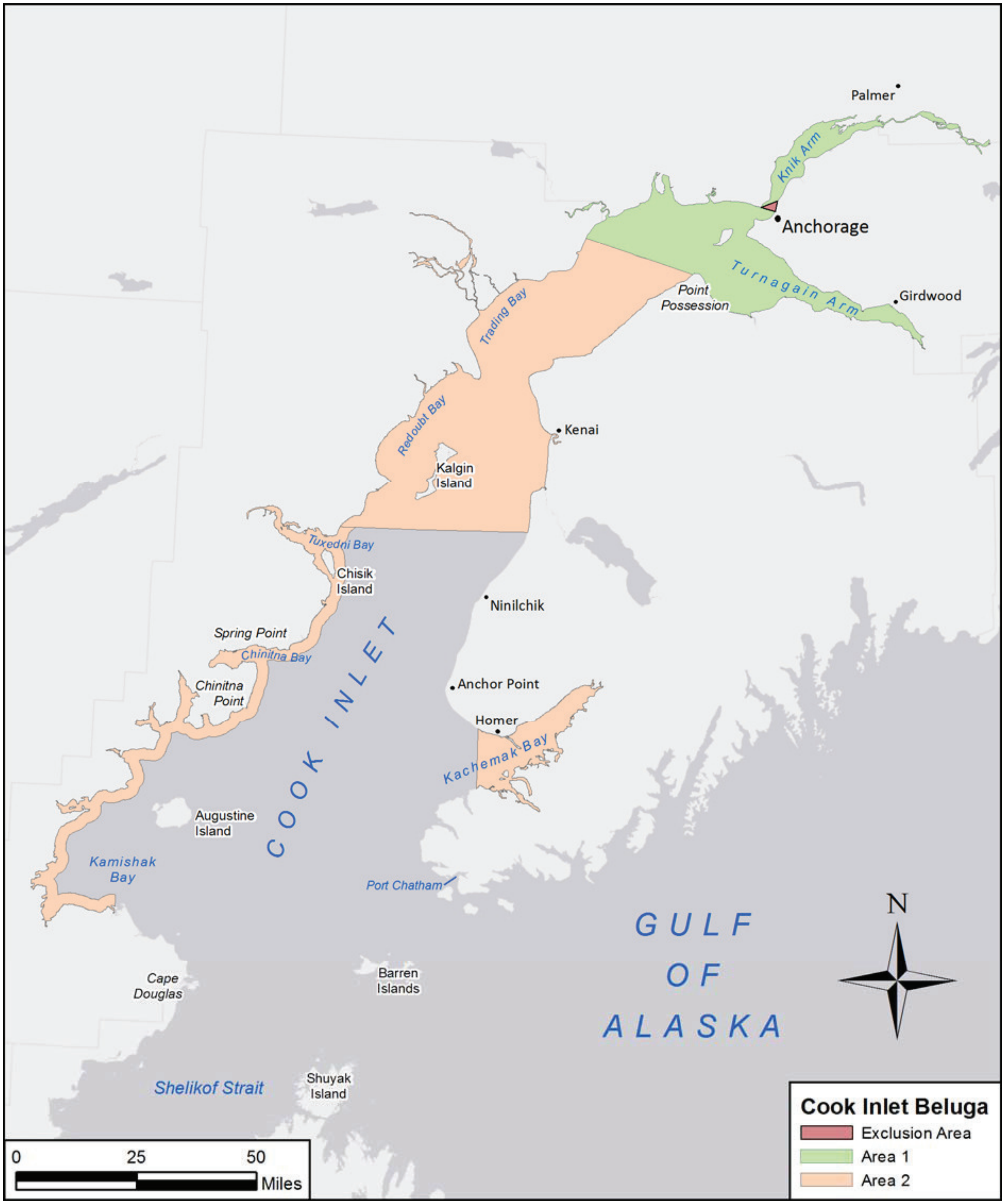

Figure 2. Critical Habitat for Beluga Whales in Cook Inlet

Figure 2: Critical Habitat for Beluga Whales in Cook Inlet

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5.5.12.3 Life History

Beluga whales are small with adult males generally ranging in size from 11 to 15 ft and females reaching 12 ft (NMFS 2007). Calves are born dark gray to brownish-gray with the color lightening to a yellow-white in adulthood. Reports of sexual maturity range from 4 to 15 years with males taking longer than females (NMFS 2005b). Calves are born in late spring and early summer, usually in the summer concentration areas following a 14-month gestation period (ADF&G 1994e). Adult females typically produce offspring once every 3 years. Members of the Cook Inlet stock have been observed calving in the Kachemak Bay, off the mouths of the Beluga and Susitna Rivers, and in the Turnagin arm (NMFS 2005b).

Belugas are social and are frequently observed in groups ranging in size from two to five to pods of more than 100 individuals. They are known to vocalize using grunts, clicks, chirps, and whistles to navigate, find prey, and communicate. During summer months, they are often found in shallow waters and feed on schooling and anadromous fish including herring, capelin, eulachon, salmon and sculpins (ADF&G 1994e). They are also known to eat octopus, squid, crabs, shrimp clams, mussels and sandworms; belugas appear to have greater feeding success in areas with dense concentrations of prey (NMFS 2005b).

5.5.12.4 Population Trends and Risks

NMFS stock assessment reports estimate the combined population of the five beluga whale stocks in U.S. waters at nearly 60,000 individuals (NMFS 2005b). NMFS reports that the population trends for the Beaufort Sea and Eastern Bering Sea stocks are unknown; these two stocks account for over 90 percent of the estimated population of beluga whales in U.S. waters (NMFS 2005b). The population of the Eastern Chukchi stock consisting of 3,710 individuals shows no evidence of decline and NMFS considers the population of the Bristol Bay stock (1,619) to be stable to increasing (NMFS 2005b). As an approximation of historical abundance, NOAA Fisheries calculated an estimate of 1,293 beluga whales in 1978 (NMFS 2005b). This number was based on a count of 479 whales from a 1978 aerial survey in Cook Inlet (Calkins 1979) with a correction factor of 2.7 developed for submerged beluga whales in Bristol Bay (DeMaster 2000), and was used to derive a value (1,300) for the beluga whale carrying capacity of Cook Inlet to be used for management purposes.

Abundance estimates for Cook Inlet beluga whales over the last several decades have ranged from 150-1300 whales. Rodrigues et al (2006) notes that estimates of historical population levels of Cook Inlet beluga whales may be somewhat problematic. This is because many surveys conducted prior to 1994 were generally non-systematic or incomplete, and failed to correct for whales not seen below the surface (Rugh et al. 2000). As a result, counts may have underestimated the number of beluga whales present in Cook Inlet.

Population trend analyses conducted on the Cook Inlet stock between June 1994 and June 1998 were constrained by the limited data available but showed a high probability that a 40 percent decline in the population had occurred during the time period (65 FR 34590, NMFS 2005b). A 2006 status review predicted a 68 percent probability that the Cook Inlet stock will continue to decline and become extinct within the next 300 years. NMFS listed the Cook Inlet beluga whale as endangered under the Endangered Species Act in 2008 (NMFS 2008 as cited by URS 2010).

The most recent abundance estimate of beluga whales in Cook Inlet, resulting from the June 2003 aerial survey is 357 (CV = 0.107) animals (NMFS unpubl. data) and is similar to the estimates of abundance for 1999 and 2000 (Angliss and Outlaw 2005).

NMFS included the Cook Inlet stock beluga whale stock on the candidate list of threatened and endangered species in 1991 (55 FR). No further action was taken immediately following, although NMFS received two petitions in 1999 to list the Cook Inlet stock under the ESA (65 FR 38778) resulting in the Cook Inlet stock being designated as depleted under the MMPA (65 FR 34590). Subsequent investigations assessed natural and human-induced sources of potential impacts that included:

- Habitat capacity and environmental change
- Stranding events
- Predation
- Subsistence harvest
- Commercial fishing
- Oil and gas development

The investigations concluded that subsistence harvests presented the most immediate threat to the stock. Although NMFS found that other potential sources of impact could have some negative effect on recovery, none were considered significant (65 FR 38778). Between 2000 and 2005 co-management agreements between NMFS and the Cook Inlet Marine Mammal Council (Council) have allowed one to two beluga whales to be harvested annually. As a result of a high number of mortalities in 2004 (20 whales), NMFS requested that the Council refrain from harvest that year. NMFS developed the *Draft Conservation Plan for the Cook Inlet Beluga Whale (Delphinapterus leucas)* in 2005 to establish goals and objectives that can be achieved cooperatively to promote the recovery of the Cook Inlet beluga whale population. The goals and objectives apply to a range of potential sources of impacts including those identified above as well as shoreline development, vessel traffic, and noise. The lack of evidence that the population is recovering even with the co-management agreements in place led NMFS to announce in March 2006 that they would be reviewing the status of Cook Inlet beluga stock under the ESA.

5.5.13 NORTHERN SEA OTTER (*Enhydra lutris kenyoni*)

The USFWS issued a final rule listing the southwest Alaska distinct population segment of the northern sea otter as threatened under the ESA on August 9, 2005 (70 FR 46366).

5.5.13.1 Geographic Boundaries and Distribution

The overall range of the sea otter extends from northern Japan to southern California. There are three recognized subspecies of *Enhydra lutris. E. lutris kenyoni,* referred to as the northern sea otter, has a range that extends from the Aleutian Islands in southwestern Alaska to the coast of the state of Washington (USFWS 2005).

Northern sea otters occur in nearshore waters which allow them access to subtidal and intertidal foraging habitats (Angliss and Lodge 2002). Visual observation of 1,251 dives by sea otters in southeast

Alaska, indicates that foraging activities typically occurs in water depths ranging from 2 to 30 m (7 to 98 ft), although foraging at depths up to 100 m (328 ft) was observed (Bodkin et al. 2004).

Sea otter movements are influenced by local climatic conditions such as storm events, prevailing winds, and in some areas, tidal conditions. They tend to move to protected or sheltered waters during storm events of high winds (USFWS 2005). The animals usually do not migrate and seldom travel unless an area has become overpopulated and food is scarce (ADF&G 1994d).

The home ranges of sea otters in established populations are relatively small. Sexually mature females have home ranges of 8 to 16 km (5 to 10 miles). Breeding males remain for all or part of the year within the bounds of their territory, which constitutes a length of coastline from 100 m (328 ft) to 1 km (0.6 mile). Male sea otters that do not hold territories may move greater distances between resting and foraging areas than territorial males (USFWS 2005).

Sea otters are found in lower Cook Inlet and Kachemak Bay at all times of the year (Klein 2011, personal communication).

5.5.13.2 Critical Habitat

On October 8, 2009, approximately 15,164 km^2 (5,855 mi^2) of critical habitat was designated for the northern sea otter (74 FR 51988). Five distinct units were identified, including: Unit 1 - Western Aleutian, Unit 2 - Eastern Aleutian, Unit 3 - South Alaska Peninsula, Unit 4 - Bristol Bay and Unit 5 - Kodiak, Kamishak, Alaska Peninsula. The Bristol Bay unit is further subdivided in 3 subunits (Amak Island, Izembek Lagoon and Port Moller/Herendeen Bay). Unit 5, the largest of the designated areas, ranges from Castle Cape in the west to Tuxedni Bay in the east, and includes the Kodiak archipelago. It contains all the Primary Constituent Elements (PCEs) necessary for the conservation of the southwest Alaska northern sea otter population and thus is subject to special management considerations and protections to minimize the risk of oil and other hazardous-material spills from commercial shipping (74 FR 51988).

Activities in the west side of lower Cook Inlet will occur within the Kamishak Bay Unit of designated critical habitat, which extends as far north as Tuxedni Bay. The critical habitat extends from the mean high tide line seaward for a distance of 100 meters, or to a water depth of 20 m. Critical habitat provides the physical and biological features—the primary constituent elements (PCEs)— essential to the conservation of this species. The primary constituent elements of sea otter critical habitat are 1) shallow, rocky areas less than 2 m (6.6 ft) in depth where marine predators are less likely to forage; 2) nearshore waters within 100 m (328.1 ft) from the mean high tide line that may provide protection or escape from marine predators; 3) kelp forests, which occur in waters less than 20 m (65.6 ft) in depth, that provide protection from marine predators; and 4) prey resources within the areas identified by PCEs 1, 2, and 3 that are present in sufficient quantity and quality to support the energetic requirements of the species (Klein 2011, personal communication). Critical habitat for northern sea otter can be seen in Figure 3 below.

Figure 3: Northern Sea Otter Critical Habitat in Cook Inlet

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5.5.13.3 *Life History*

Sea otters mate at all times of the year, and young may be born in any season; however, in Alaska, most pups are born in late spring (ADF&G 1994d). Females typically give birth in the water, although they have been observed giving birth on shore (USFWS 2005). Male sea otters appear to reach sexual maturity at 5-6 years of age, and have a lifespan of about 10 to 15 years. Female sea otters reach sexual maturity at 3- 4 years of age and have a lifespan of about 15 to 20 years (USFWS 2005). Sea otters are gregarious and may become concentrated in an area, sometimes resting in pods of fewer than 10 to more than 1,000 animals (ADF&G 1994d).

The search for food is one of the most important daily activities of sea otters, as large amounts are required to sustain the animal in healthy condition. Sea urchins, crabs, clams, mussels, octopus, other marine invertebrates, and fishes make up the normal diet of sea otters (ADF&G 1994d).

5.5.13.4 *Population Trends and Risks*

Prior to commercial exploitation, the world population of sea otter in the North Pacific ocean was estimated to be between 150,000 and 300,000 individuals (USFWS 2005). Over the 170 years of commercial exploitation, sea otters were hunted to the brink of extinction first by Russian and later by American fur hunters. Sea otters became protected under the International Fur Seal Treaty of 1911; at that time the entire population may have been reduced to between 1,000 and 2,000 animals (USFWS 2005).

By the 1980s, sea otters in southwest Alaska had increased in abundance and re-colonized much of their former range. However, aerial surveys conducted in 2000 indicated widespread declines throughout the Aleutian Islands, particularly in the central Aleutians. Doroff et al. (2003) estimated that sea otter populations had decreased approximately 70 percent from a similar survey conducted in 1992. Despite the dramatic declines in the Aleutians, populations in the Kodiak archipelago do not appear to follow the same trend (Burn and Doroff 2005). At present, the population in southwest Alaska is estimated at 53,674 animals (USFWS 2010); 54 percent (28,955 animals) of this total occurs within the Kodiak Archipelago. Throughout the remainder of their range, sea otter populations have declined in the range of 39 percent to 74 percent.

5.5.14 STELLER SEA LION *(Eumetopias jubatus)*

The NMFS listed Steller sea lion as threatened, by emergency interim rule, on April 5, 1990 (55 FR 12645). The emergency rule listing, which had duration of 240 days, was followed by a final listing of Steller sea lion as threatened on November 26, 1990 (55 FR 49204). On May 5, 1997, the NMFS issued a final rule that reclassified Steller sea lions into two distinct population segments (62 FR 24355). The Steller sea lion population west of 144°W longitude (a line intersecting the Alaskan coastline near Cape Suckling) was reclassified as endangered; the sea lion population to the east of this line retained its ESA-listing status as threatened; both stocks are therefore designated as "depleted" under the MMPA.

5.5.14.1 Geographic Boundaries and Distribution

The Steller sea lion is distributed around the North Pacific Ocean rim from northern Hokka, Japan along the western North Pacific northward through the Kuril Islands and Okhotsk Sea, then eastward through the Aleutian Islands and central Bering Sea, and southward along the eastern North Pacific to the Channel Islands, California (NMML 2004b). Two distinct populations (western and eastern) are thought to occur within this range, with the dividing line being designated as 144°W longitude (62 FR 24355).

There is designated critical habitat for Steller sea lion and other habitat considered as critical habitat by the NMFS within the lease-sale area: at Cape Douglas, the Barren Islands, and marine areas adjacent to the southwestern Kenai Peninsula, and at the extreme southern end of Cook Inlet. There is additional critical habitat—including rookeries, haulouts, and marine foraging areas for the western population stock—in areas near the lease-sale area, including Shelikof Strait, and areas along the southern side of the Alaska Peninsula (MMS 2003).

5.5.14.2 Critical Habitat

In 1993, NMFS issued a final rule designating critical habitat for the Steller sea lion, including all U.S. rookeries, major haulouts in Alaska, horizontal and vertical buffer zones (5.5 km [3.4 mi]) around these rookeries and haulouts, and three aquatic foraging areas in north Pacific waters: Sequam Pass, southeastern Bering Sea shelf, and Shelikof Strait (58 FR 45269). This final rule was amended on June 15, 1994, to change the name of one designated haulout site from Ledge Point to Gran Point and to correct the longitude and latitude of 12 haulout sites, including Gran Point (59 FR 30715).

Critical habitat includes a terrestrial zone that extends 3,000 ft. (0.9 km) landward from the baseline or base point of each major rookery and major haulout in Alaska. Critical habitat includes an air zone that extends 3,000 ft. (0.9 km) above the terrestrial zone of each major rookery and haulout area measured vertically from sea level. Critical habitat within the aquatic zone in the area east of 144°W longitude (ESA threatened population) extends 3,000 ft. (0.9 km) seaward in state and federally managed waters from the base point of each rookery or major haulout area. Critical habitat within the aquatic zone in the area west of 144°W longitude (ESA endangered population) extends 20 nautical miles (37 km) seaward in state and federally managed waters from the baseline or base point of each rookery or major haulout area (58 FR 45269). Critical Habitat in Cook Inlet can be seen in Figure 4 below

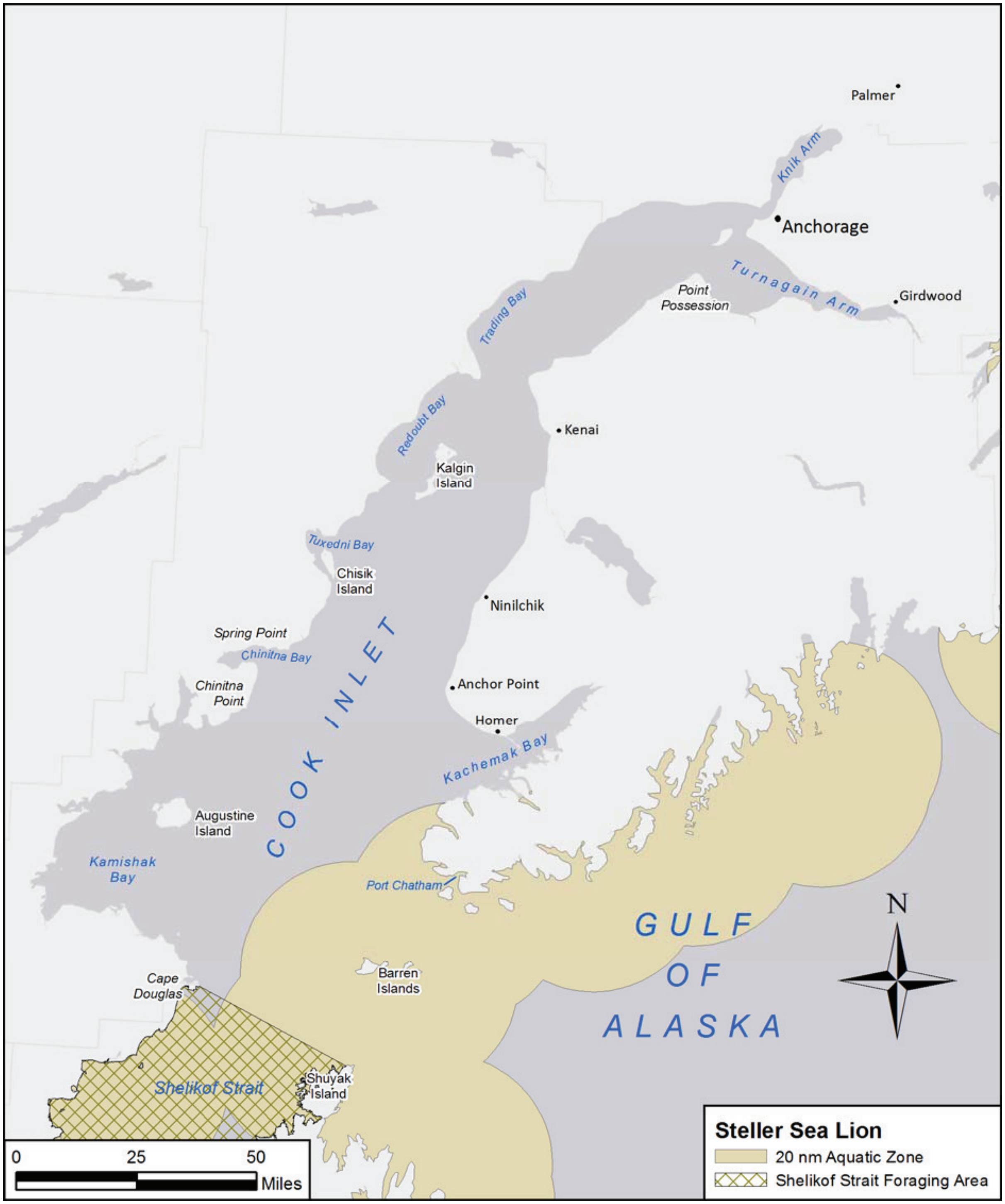

Figure 4: Steller Sea Lion Critical Habitat in Cook Inlet

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5.5.14.3 Life History

The breeding season for Steller sea lions is from May to July, where the animals congregate at rookeries and the males defend territories, mating occurs, and the pups are born. Non-reproductive animals congregate to rest at more than 200 haulout sites where little or no breeding occurs. Bulls become sexually mature between 3 and 8 years of age, but typically are not able to gain sufficient size and successfully defend territory within a rookery until 9 to 10 years of age. Females reach sexual maturity and mate at between 4 and 6 years of age and typically bear a single pup each year. Sea lions continue to gather at both rookeries and haulout sites throughout the year, outside of the breeding season (NMML 2004b). Habitat types that typically serve as rookeries or haulouts include rock shelves, ledges, slopes, and boulder, cobble, gravel, and sand beaches. Seasonal movements occur generally from exposed areas in summer to protected areas in winter (ADF&G 1994c).

When foraging in marine habitats, Steller sea lions typically occupy surface and mid water ranges in coastal regions. They are opportunistic predators and feed on a variety of fish (walleye Pollock, Atka mackerel (*Pleurogrammus monopteryguius*), Pacific herring, capelin, sand lance, Pacific cod (*Gadus macrocephalus*), salmon, and invertebrates (squid, octopus) (ADFG 1994cNMML 2004b).

5.5.14.4 Population Trends and Risks

In 1980, the world population of Steller sea lion was estimated to be between 245,000 and 290,000 (Loughlin et al. 1992). The western population of Steller sea lion declined approximately 5.0 percent per year over the period of 1991 to 2000, while the eastern population has increased at about 1.7 percent per year (Loughlin and York 2000). Based on data collected in 2003 and 2004, Fritz and Stinchcomb (2005) cautiously concluded that the decline of the western population within the Alaskan territory has slowed and showed a modest increase estimated at 2.4 to 4.2 percent. More recent surveys appear to confirm the stability of the population. Fritz et al. (2008a) found the Stellar sea lion population remained unchanged between 2004 (N=23,107) and 2007 (N=23,118) throughout much its range from Cape St. Elias to Tanaga Island (145° to 178° W). These finding were further supported through aerial surveys conducted in 2008 (Fritz et al. 2008b)

A substantial amount of research has been devoted to trying to determine the cause(s) of the Steller sea lion decline, whose number has dropped by more than 80 percent in the last three decades in Alaskan waters (National Academies 2002). Currently, there is no consensus on a single causal factor, and it is likely that many factors could have contributed to the decline of this species (NMML 2004b). The hypotheses can be divided into two categories (National Academies 2002); those that propose factors that would affect the overall health and fitness of sea lions and those that propose factors that would directly kill sea lions regardless of their general health. The first four items listed below fall into the former category; the last five items fall within the latter category:

- Reduced prey availability or prey quality due to large-scale fishing operations
- Climate changes in the 1970s that may have affected the availability of quality of prey
- Non-fatal diseases that inhibit sea lions' ability to forage for food
- Impairment (reduced fecundity) caused by the consumption of contaminated prey
- Predation by killer whales

- Incidental mortality caused by fishing operations
- Illegal harvest
- Subsistence harvesting
- Fatal diseases caused by contagious pathogens or increased exposure to pollutants

While there may not be consensus on a single causative factor for thedecline of sea lion abundance in Alaskan waters, nutritional stress is probably the leading hypothesis (NMFS 1995b, Porter 1997). Sea lion declines in abundance have coincided with the declines of other Alaskan pinniped stocks (harbor seal and northern fur seal) and some sea bird breeding colonies. Over the same period of these declines, there has been a rapid growth in groundfish fisheries in Alaska, which suggests that competition by fisheries and reduced prey availability may be limiting the growth and reducing the fitness of sea lions (Porter 1997). Pollock make up over 50 percent of the prey consumed by sea lions; the removal of large quantities of Pollock, and other groundfish that could provide alternative prey, by commercial fisheries may have caused increased nutritional stress and reduced the fitness of sea lions resulting in increased mortality rates.

5.5 Essential Fish Habitat in Project Area

An EFH assessment is applied to the defined EFH for all species managed under a federal Fisheries Management Plan (FMP). Currently three FMPs have fisheries resources that might be affected by the proposed action:

- The Fisheries Management Plan for Groundfish of the Gulf of Alaska
- The Fisheries Management Plan for Scallop Fishery off Alaska
- The Fisheries Management Plan for the Salmon Fisheries in the exclusive economic zone (EEZ) off the Coast of Alaska

The NMFS has recently updated an environmental impact statement (EIS) defining EFH for the Alaskan region affected by these and other FMPs (NMFS 2010c). The definition NOAA Fisheries uses for a species' EFH is based on the subset of the species' population and is 95 percent of the population for a particular life stage, if life history data are available for the species. Where information is insufficient and a suitable proxy cannot be inferred, EFH is not described for that species life stage.

The EFH species and life stages present in the Gulf of Alaska are shown for groundfish, weathervane scallops, and salmon in Tables 3-1, 3-2, and 3-3, respectively. EFH species in Cook Inlet is mapped in figure 5.

Table 3-1. Gulf of Alaska Groundfish EFH Species Life Stages Present in the Project Area					
Gulf of Alaska species	**Eggs**	**Larvae**	**Early juvenile**	**Late juvenile**	**Adult**
Walleye pollock	1	1	-	1	1
Pacific cod	2	1	-	1	1

Table 3-1. Gulf of Alaska Groundfish EFH Species Life Stages Present in the Project Area					
Gulf of Alaska species	**Eggs**	**Larvae**	**Early juvenile**	**Late juvenile**	**Adult**
Yellowfin sole	2	2	-	2	2
Arrowtooth flounder	-	1	-	1	1
Rock sole	-	1	-	1	1
Alaska plaice	1	2	-	2	2
Rex sole	1	1	-	1	1
Dover sole	1	1	-	1	1
Flathead sole	1	1	-	1	1
Sablefish	2	1	-	1	1
Shortraker/rougheye rockfish	-	1	-	2	2
Northern rockfish	-	-	-	-	2
Thornyhead rockfish	-	1	-	2	2
Yelloweye rockfish	-	1	-	2	2
Dusky rockfish	-	1	-	-	2
Atka mackerel	2	2	-	-	2
Sculpins	-	-	-	1	1
Skates	-	-	-	-	1
Sharks	-	-	-	-	-
Forage fish complex	-	-	-	-	-
Squid	-	-	-	1	1
Octopus	-	-	-	-	-

- = no information is available to define EFH in the Gulf of Alaska.
1 = life stage with defined EFH in the project area.
2 = life stage with defined EFH, but none in the project area. Source: NMFS 2005c

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Table 3-2. Alaska Scallops' EFH Life Stages Present in the Project Area					
Scallop species	**Egg**	**Larvae**	**Early juvenile**	**Late juvenile**	**Adult**
Weathervane	-	-	-	1	1

- = no information is available to define EFH in the Gulf of Alaska
1 = life stage with defined EFH in the project area
2 = life stage with defined EFH, but none in the project area
Source: NMFS 2005c.

Table 3-3. Salmon Species' EFH Life Stages Present in the Project Area						
Salmon species	**Freshwater eggs**	**Freshwater larvae and juveniles**	**Estuarine juveniles**	**Marine juveniles**	**Marine immature and maturing**	**Freshwater adults**
Pink	2	2	1	1	1	2
Chum	2	2	1	1	1	2
Sockeye	2	2	1	1	1	2
Chinook	2	2	1	1	1	2
Coho	2	2	1	1	1	2

- = no information is available to define EFH in the Gulf of Alaska.

1 = life stage with defined EFH in the project area.

2 = life stage with defined EFH, but none in the project area.

Source: NMFS 2005c.

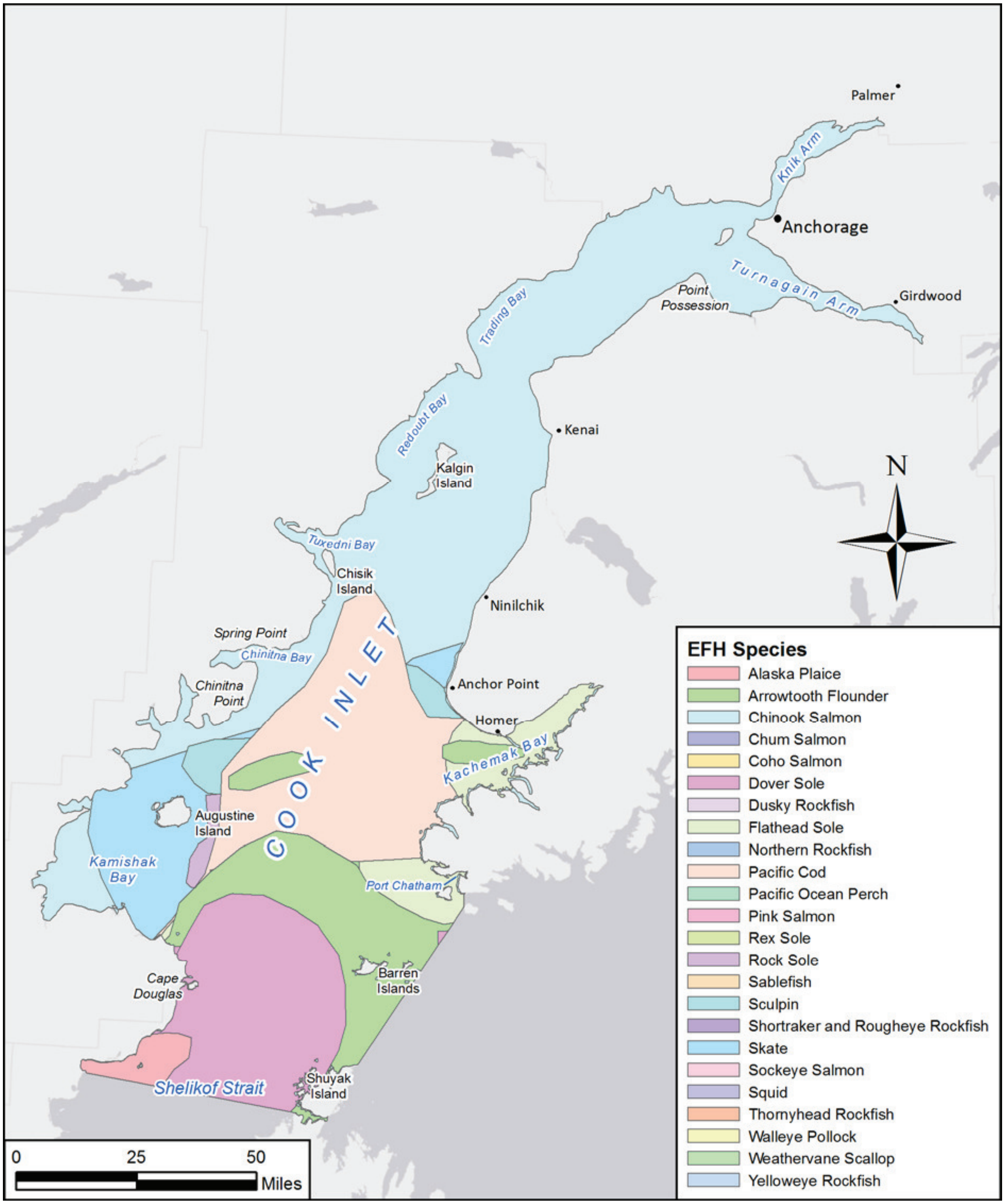

Figure 5: Essential Fish Habitat in Cook Inlet

5.6 SPECIES ESSENTIAL FISH HABITAT DESCRIPTIONS

This section presents information on EFH characteristics and general life history for only species with defined EFH in the project area. Species without defined EFH in the project area are not discussed. With the exception of EFH for salmon species, all other defined EFH in the project area is limited to the outer third of Cook Inlet, with most near or just outside the Cook Inlet entrance. (See Appendix D of NMFS 2005c. & NMFS 2010c)

5.6.1 Walleye Pollock

The egg, larval, late juvenile and adult life stages of walleye pollock have essential fish habitat in the project area. With the exception of the adult life stage, which extends into Kachemak Bay, all others are restricted to extending slightly inside the Cook Inlet entrance. Eggs, which are pelagic, are found at depths from 0 to 1000 m. The epipelagic larvae have a similar distribution. Juveniles and adults are most often in the lower and middle portions of the water column, at depths less than 200 m (656 ft) for juveniles and between approximately 10 to 1000 m (3.3 – 3280 ft) for adults. These life stages have no substrate preference. Seasonal migrations occur from the outer continental shelf to shallow waters (90 to 140 m, or 295 to 459 ft) for spawning. Spawning takes place in early spring; the eggs hatch in about 10 to 20 days, depending on water temperature, and larvae spend 20 to 30 days in the surface waters.

5.6.2 Pacific Cod

EFH for larvae, late juveniles, and adults is present in the NPDES permit area, however only the adult stage EFH extend well into Cook inlet, while others are restricted to near the entrance. Pacific cod is generally a demersal species that occurs on the continental shelf and upper continental slope (NMFS 2010C). Spawning habitat occurs along the continental shelf and slope from about 40 to 290 m (131 to 951 ft); spawning typically occurs from January to April. The optimal conditions for embryo development are water temperatures between 3 and 6 °C (37 – 43 °F) and dissolved oxygen concentrations from 2 to 3 ppm saturation. The larvae are epipelagic, occurring primarily in the upper 45 m (148 ft) of the water column shortly after hatching, and they move downward in the water column as they grow. The larvae occur primarily in waters less than 100 m (328 ft) deep over soft substrate. Juvenile and adult EFH occurs in the lower portion of the water column in the inner, middle, and outer continental shelf from 0 to 200 m (656 ft), where their preferred substrate is soft sediment primarily from mud to gravel (NMFS 2005c).

5.6.3 Arrowtooth Flounder

EFH in the project area includes larvae, near the Cook Inlet entrance, and juveniles and adults, extending into Cook Inlet as far as Kachemak Bay. All life stages of Arrowtooth flounder occur along the entire continental shelf region with water depths ranging from 0 to 3000 m. Spawning is thought to occur from September through March. Larvae are planktonic for at least 2 to 3 months until metamorphosis occurs; juveniles usually inhabit shallow areas until reaching 10 to 15 cm in length (Martin and Clausen 1995). Adults are found in continental shelf waters until age 4, and they occupy both shelf and deeper slope waters at older ages with highest concentrations at 100 to 200 m (328 – 656 ft) (NMFS 2005c). Both adults and juveniles are often found over soft substrate, typically mud and sand, in the lower portion of the water column.

5.6.4 Rock Sole

Project area EFH for larvae occurs near the Cook Inlet entrance, while juvenile and adult EFH extends beyond the Kachemak Bay entrance. All life stages of rock sole except the egg stage occur in the inner continental shelf regions. Spawning takes place during late winter/early spring near the edge of the continental shelf at depths from 125 to 250 m (410 to 820 ft). The eggs are demersal and adhesive. The larvae are planktonic for at least 2 to 3 months until metamorphosis occurs. The juveniles inhabit shallow waters until at least age 1 (NMFS 2005c). Juveniles and adults occur over moderate to softer substrates of sand, gravel, and cobble, mostly at depths from 0 to 200 m.

5.6.5 Alaska Plaice

EFH for Alaska plaice in the project area includes eggs, late juveniles, and adults. The EFH for all three life stages is at the outer edge of the project area, outside Cook Inlet. Alaska plaice is considered a "deep water" species in the Gulf of Alaska groundfish management area, located generally along the entire continental shelf and the slope (NMFS 2010C). Eggs are present over a range of depths (0 to 500 m) in the spring. Juvenile and adult EFH is in the lower portion of the water column at depths of 0 to 200 m, over sand and mud substrate (NMFS 2005c).

5.6.6 Rex Sole

All life stages of Rex sole EFH is present in the project area. All EFH is present only in the NPDES area at the entrance of Cook Inlet. Pelagic eggs and larvae are present over a range of depths (0 to 500 m) from October to June (Abookire 2006). EFH of juveniles and adults is in the lower portion of the water column at depths of 0 to 200 m, but are most abundant at depths between 100 and 200m (NMFS 2010C). Juvenile and adult individuals can be found over gravel, sand, and mud substrate (NMFS 2005c).

5.6.7 Dover Sole

The project area EFH for Dover sole egg, larval, late juvenile, and adult life stages is present only near the Cook Inlet entrance. This fish is considered a "deep water flatfish" in the Gulf of Alaska management area. The EFH ranges to great depths (0 to 3,000 m) for planktonic larvae and eggs, although adult and juvenile EFH is less deep (0 to 500 m) in the middle and outer shelf and upper slope areas, occurring in the lower portion of the water column over soft substrate of sand and mud (NMFS 2005c).

5.6.8 Flathead Sole

The flathead sole EFH for eggs and larvae extends inside the Cook Inlet entrance, while late juvenile and adult habitat extends into Kachemak Bay in the project area. The adults are benthic and have separate winter spawning and summer feeding distributions. The fish over-winter near the continental shelf margin and then migrate onto the mid and outer continental shelf areas in the spring to spawn in deepwater areas near the margin of the continental shelf. The eggs are pelagic, and the larvae are planktonic, and usually inhabit shallow areas. Egg and larval EFH ranges from 0 to 3000 m, while juveniles' and adults' EFH is shallower (0 to 200 m) and occurs over sand and mud substrate. Like all flatfish, flathead sole occur in the lower portion of the water column.

5.6.9 Sablefish

The EFH for larval, juvenile, and adult sablefish is present only at the entrance of the Cook Inlet in the project area. Spawning is pelagic at depths of 300 to 500 m (984 to 1,640 ft) near the edges of the continental slope. Larvae are oceanic through the spring; by late summer, small juveniles (10 to 15 cm [4 to 6 in]) occur along the outer coasts of southeast Alaska, where they predominantly spend their first winter. First- to second-year juveniles are found primarily in nearshore bays; they move to deeper offshore waters as they age, with EFH habitat at depths of 200 to 1,000 m (656 – 3280 ft). Adults are found on the outer continental shelf mainly on the slope and in deep gullies at typical depths of 200 to 1000 m (656 – 3280 ft), over varied habitat, usually in soft substrate (NMFS 2005c).

5.6.10 Rockfish

Some 32 rockfish species are present in Alaskan waters, but only 7 rockfish species (Table 3-1) have designated EFH in the Gulf of Alaska (NMFS 2005c). The EFH of larvae for all rockfish species is grouped, not separated by species. Within the project area rockfish larvae are present only near the Cook Inlet entrance. No juvenile or adult EFH for any of the seven rockfish species is present in the project area because all habitat for these life stages is present in deeper water, often near the continental shelf, or in other nearshore areas of the Gulf of Alaska. The EFH for rockfish larvae is characterized as being in the entire shelf (0 to 200 m [656 ft]) and slope areas (200 to 3000 m [656 – 9843 ft]), except the EFH for Pacific Ocean perch, which extends only to a 500 m (1640 ft) depth in the upper slope area. In general, rockfish tend to be demersal as late juveniles and adults, although some species are pelagic occupying midwater areas. Many species are associated with rocky substrates. Rockfish have internal fertilization and release live young in the spring (NMFS 2005c).

5.6.11 Sculpins

Though a demersal fish, the EFH for juvenile and adult sculpins in the project area is present only in a narrow band extending from Kachemak Bay in the east to Kamishak Bay, north of Augustine Island, to the west (NMFS 2005c). Both juveniles and adults are present in the lower portion of the water column in the inner, middle, and outer shelf (0 to 200 m) and also in the upper slope (200 to 500 m) in the Gulf of Alaska, over varied substrate (mud to rock). Most spawning occurs in the winter, and some species have internal fertilization. Typically eggs are laid in rocks, where malesguard them. Larvae often have diel migration (near the surface at night) and might be present year-round.

5.6.12 Skates

The EFH for adult skates extends well into the Cook Inlet project area, beyond Kachemak Bay, and covers most of outer third of the Inlet (NMFS 2005c). Adult EFH is found in waters of 0 to 500 m (1640 ft) on shelf and upper slope areas. Adult skates are present in the lower portion of the water column over varied substrate from mud to rock. Skates are oviparous, fertilization is internal, and eggs are deposited in a horny case for incubation. After hatching, the juveniles likely remain in shelf and slope waters, but their distribution is unknown. No data on habitat requirements or movement are available (NMFS 2005c).

5.6.13 Squid

The EFH for juvenile and adult squid is present only in the outer portion of the project area, between Cape Douglas and the Barren Islands, outside Cook Inlet. Juveniles and adults use the entire water column over the shelf (0 to 500 m [1640 ft]) and all the slope (500 to 1,000 m [1640 – 3280 ft]) regions (NMFS 2005c). Reproduction is poorly known, but fertilization is internal, and squid lay eggs in gelatinous masses in water 200 to 800 m (656 – 2625 ft) deep. Young juveniles are often in water less than 100 m deep, while older juveniles and adults are more often in waters 150 to 500 m (492 – 1640 ft) deep. Spawning occurs in the spring, over rocks, shells, and other hard substrate (NMFS 2010C).

5.6.14 Weathervane Scallop

The designated EFH for late juvenile and adult weathervane scallops extends well into the outer half of Cook Inlet to beyond the entrance to Kachemak Bay. The EFH habitat of late juveniles and adults is along the seafloor in the middle (50 to 100 m [164 – 328 ft]) to outer (100 to 200 m [328 – 656 ft]) shelf areas. It is generally elongated along the current lines, as is apparent in the EFH in Cook Inlet, which tends to be in an elongated distribution toward the middle of the inlet (NMFS 2005). The scallops are generally over clay to gravel substrates. Although they are capable of swimming, they usually remain along seafloor depressions. Fertilization is external, and pelagic larvae drift for a month before they settle to the seafloor (NMFS 2005c).

5.6.15 Pink Salmon

The essential fish habitat for pink salmon within the project area includes estuarine juvenile, marine juvenile, and marine immature and maturing adults (NMFS 2005c). The estuarine EFH is the mouth areas of streams from the mean high tide line to the salinity transition zone. All other marine life stage EFH includes the entire project area because EFH for this species extends from the mean higher tide line to the 200 nautical mile limit of the U.S. Exclusive Economic Zone (EEZ). This species is pelagic to a depth of about 200 m. Pink salmon spawn in small streams within a few miles of the shore, within the intertidal zone, or at the mouths of streams. Eggs are laid in stream gravels. After hatching, salmon fry move downstream to the open ocean. Pink salmon stay close to the shore, moving along beaches during their first summer feeding on plankton, insects, and small fish. At about 1 year of age, pink salmon move offshore to ocean feeding areas.

5.6.16 Chum Salmon

The EFH for chum salmon within the project area includes estuarine juveniles, marine juveniles, and marine immature and maturing adults (NMFS 2005c). The estuarine EFH is the mouth areas of streams from the mean high tide line to the salinity transition zone. All other marine life stage EFH includes the entire project area because EFH for this species extends from the mean higher tide line to the 200-nautical-mile limit of the U.S. EEZ. This species is pelagic to a depth of about 200 m. Most chum salmon spawn in small streams within a few miles of the shore, or within the intertidal zone, but some travel great distances up large rivers. Eggs are laid in stream gravels. After hatching, salmon fry move downstream to the open ocean

5.6.17 Sockeye Salmon

The EFH for sockeye salmon within the project area includes estuarine juveniles, marine juveniles, and marine immature and maturing adults (NMFS 2005c). The estuarine EFH is the mouth areas of streams from the mean high tide line to the salinity transition zone. All other marine life stage EFH includes the entire project area because EFH for this species extends from the mean higher tide line to the 200-nautical-mile limit of the U.S. EEZ. This species is pelagic to a depth of about 200 m. Sockeye spawn in stream systems with lakes in late summer and autumn. After 1 to 3 years in fresh water lakes, the fry move downstream to the open ocean.

5.6.18 Chinook Salmon

The EFH for Chinook salmon within the project area includes estuarine juveniles, marine juveniles, and marine immature and maturing adults (NMFS 2005c). The estuarine EFH is the mouth areas of streams from the mean high tide line to the salinity transition zone. All other marine life stage EFH includes the entire project area because EFH for this species extends from the mean higher tide line to the 200-nautical-mile limit of the U.S. EEZ. This species is pelagic to a depth of about 200 m. Chinook spawn in small and large streams, and the eggs are laid in stream gravels. After hatching, salmon fry move downstream to the open ocean. Freshwater ecosystems in the Pacific Northwest represent essential fish habitat for sustaining the diversity and abundance of Chinook salmon throughout the Alaska EEZ (NMFS 2010C).

5.6.19 Coho Salmon

The EFH for coho salmon within the project area includes estuarine juveniles, marine juveniles, and marine immature and maturing adults (NMFS 2005c). The estuarine EFH is the mouth areas of streams from the mean high tide line to the salinity transition zone. All other marine life stage EFH includes the entire project area because EFH for this species extends from the mean higher tide line to the 200-nautical-mile limit of the U.S. EEZ. This species is pelagic to a depth of about 200 meters.

Coho salmon spawn in small streams and the eggs are laid in stream gravels. After 1 to 3 years in fresh water ponds, lakes, and stream pools, the salmon fry move downstream to the open ocean.

6.0 DETERMINATION OF UNREASONABLE DEGRADATION

6.1 CHEMICAL TOXICITY OF DISCHARGES

6.1.1 Drilling Fluids Toxicity

Drilling fluids are complex mixtures, and there appear to be several reasons for its toxicity. Some of the apparent toxicity may be due to physical effects, such as particle size coagulations, abrasions, and so on. There is, however, some chemical toxicity associated with drilling fluids that produces or contributes in part to the lethality in acute toxicity tests (Tetra Tech 2006).

Oxygen demand appears strongly correlated with toxicity in laboratory toxicity tests. Spearman Rank correlations of 96-hour LC_{50} data and 5-day biochemical oxygen demand/ultimate oxygen demand (BOD_5/UOD) data showed a remarkably strong correlation, especially with BOD_5 data derived with artificial sea water and activated seed. These data showed a correlation of 0.97 with toxicity. All BOD_5/UOD values showed correlations of 0.87 to 0.97 (BOD_5) and 0.91 to 0.95 (UOD), but total organic carbon/chemical oxygen demand (TOC/COD) values gave correlations of 0.64 to 0.67. Given the absence of oxygen demand data, no such correlation could be developed for nongeneric fluids. Another indicator of the large inherent oxygen demand of drilling fluids is that dissolved oxygen levels in test environments dropped below normal, despite the continuous aeration of test media that followed pre-aeration of the test material. This was especially noted during the first day of testing, during which dissolved oxygen levels were depressed concentration dependently by the test fluids (USEPA 2000).

A variety of Alaskan marine organisms have been exposed to drilling fluid in laboratory or field experiments. Most of these studies have addressed short-term acute effects in a relative or *screening* sense, with little effort directed at separating chemical from physical causes. A few studies have looked at chronic sublethal effects and bioaccumulation of heavy metals from drilling fluid. Chronic refers to a stimulus that lingers or continues for a relatively long period of time, often one-tenth of the life span of an organism or more (USEPA 1991). Chronic tests assess the effect on survivability, growth, maturation, or reproduction, and the results are typically reported as a median effect concentration (EC_{50} - concentrations at which a designated effect is displayed by 50 percent of the test organisms). Because drilling discharges are episodic and typically only a few hours in duration, organisms that live in the water column are not likely to have long-term exposures to drilling fluids; risks to these organisms are best assessed using acute toxicity data. Benthic organisms, particularly sessile species, are likely to be exposed for longer time periods; risks to these organisms are best assessed with chronic toxicity data (Tetra Tech 2006).

Drilling fluid toxicity tests have been performed using whole fluids or various component fractions, such as the suspended particulate phase (SPP) or fluid aqueous fraction. The variability and complexity in the composition of fluids is reflected in the results and interpretation of toxicity tests. Test results of sample splits of the same fluid performed at two different laboratories have differed by an order of magnitude. In such cases, laboratory procedure or sample handling is a significant factor. Different batches of the same generic fluid have shown significantly different toxicities. In this case, different proportions of major constituents (as allowed by fluid type definition) may be a factor. EPA has attempted to improve consistency in toxicity test results by requiring standard procedures for sample handling and testing that has resulted in consistent test results. The current effluent guidelines require toxicity testing for the SPP. The extrapolation of single species toxicity tests to overall effects in the ecosystem still has a large, inherent uncertainty (Tetra Tech 2006).

6.1.1.1 Acute Lethal and Sublethal Effects

The effects of drilling fluids on biological organisms are most commonly assessed by conducting acute laboratory toxicity tests. Unfortunately, in many cases, comparison of toxicity test results obtained in different studies are difficult because different drilling fluids were used, the animals were exposed to different portions of drilling fluid (liquid, suspended particulates, or solids) that may have been prepared in a different manner, or experimental procedures differed between investigators. Nevertheless, results obtained in the majority of studies to date have generally indicated low toxicity (Tetra Tech 2006).

In a summary of over 415 toxicity tests of 68 fluids using 70 species, 1–2 percent exhibited an LC_{50} ranging from 100 to 999 ppm, 6 percent exhibited an LC_{50} ranging from 1,000 to 9,999 ppm, 46 percent exhibited an LC_{50} ranging from 10,000 to 99,999 ppm, and 44 percent exhibited an LC_{50} greater than 100,000 ppm (USEPA 1985). Two to three percent of the data were not usable. A significant difference was noted between the toxicity of generic fluids, which appear to have acute, lethal toxicity characteristics similar to the distribution of the larger data set described above, and a series of 11 nongeneric fluids provided to EPA by the Petroleum Equipment Supplies Association. These latter fluids, as a group, appear to be substantially more toxic than would be anticipated from the toxicity distribution of either the generic fluids or the larger data set. Whole fluids appear to be more toxic than aqueous or particulate fractions. The SPP appears to be more toxic than the other individual phases (Tetra Tech 2006).

Under the proposed Cook Inlet Exploration general permits, discharge of fluids with a 96-hour LC_{50} of less than 30,000 ppm SPP is prohibited.

Drilling fluid toxicity data compiled by EPA Region 10 from Alaskan exploratory and production wells indicate that the fluids used in all current and recent operations are acutely toxic only to a slight degree to mysid shrimp (*Mysidopsis bahia)*. The LC_{50} results for the 91 valid toxicity test data points ranged from 2,704 to 1,000,000 ppm SPP with a mean of 540,800 ppm. Only 7 of the 91 tests had an LC_{50} less than the 30,000 ppm limit. Some of the records in this database were not included in the above statistics due to quality control issues including pH values outside of range, incomplete reports, and other reasons. (Tetra Tech 2006).

Petrazzuolo (1981) has ranked organisms according to their sensitivity to drilling fluids in tests and found the following order of decreasing sensitivity: copepods and other plankton, shrimp, lobsters, mysids and finfish, bivalves, crabs, amphipods, echinoderms, gastropods, and polychaetes, and isopods. Larval organisms are more sensitive than adult stages (maximally 20-fold); animals are more susceptible during molting (Tetra Tech 2006).

The majority of Alaskan organisms apparently show high tolerance to acute exposure to drilling fluid. Sublethal effects observed following acute exposure have included alteration of respiration and filtration rates, enzyme activities, and behavior. There are several Alaskan taxa that have not been exposed to drilling fluid but may be relatively sensitive. The temperate copepod, *Acartia tonsa*, has exhibited one of the lowest LC_{50} concentration (100 ppm) of any organism in a drilling fluid. Alaskan copepods have not been tested, but there is no reason to believe their tolerances would fall outside variability in tolerances of other marine copepods (Tetra Tech 2006).

In general, planktonic and larval forms appear to be the most sensitive of the Alaskan organisms that have been exposed to drilling fluid in acute lethal bioassays; however, not all planktonic organisms are sensitive to short-term exposure to drilling fluids. Carls and Rice (1981) found several drilling fluids to have low toxicity to the larvae of six Alaskan species of shrimp and crab. The 96-hour LC_{50} for the SPP of a drilling fluid sea water mixture ranged from 500 to 9,400 ppm. Toxicity was far less when the particulates were removed: the 96-hour LC_{50} ranged from 5,800 to 119,000 ppm (Tetra Tech 2006).

Houghton et al. (1981) conducted a study on several species of crustaceans, including a shrimp (*Pandalus hypsinotus*), a mysid (*Neomysis integer*), an amphipod (*Eogammarus confervicolus*), an isopod (*Gnorimosphaeroma oregonensis*), and pink salmon fry (*Onchorhyncus gorbuscha*). These species were exposed to used high-density lignosulfonate drilling fluid obtained from lower Cook Inlet, Alaska. Pink salmon fry were the most sensitive with a 96-hour LC_{50} of 3,000 ppm for SSP. The lowest crustacean concentration was ten times higher (Neff 1981).

Seven arctic polymer drilling fluids were used for toxicity testing of salmon (Houghton et al. 1981). Five of the seven fluids displayed a 96-hour LC_{50} of less than 40,000 ppm for the SSP fraction; the most toxic fluid had a 96-hour LC_{50} of 15,000 ppm, and the least toxic fluid a 96-hour LC_{50} of 190,000 ppm. Clam worms (polychaetes), soft-shelled clams, purple shore crabs, and sand fleas had approximately the same sensitivity to the fluids as did the salmon. These invertebrate 96-hour LC_{50} concentrations ranged from 10,000 to more than 560,000 ppm (Neff 1981).

Unlike the water-based drilling fluids, the synthetic-based drilling fluids (SBFs) are water insoluble and do not disperse in the water column as do water-based drilling fluids, but rather sink to the bottom with little dispersion (USEPA 2000). Since 1984, EPA has used the SPP toxicity test, an aqueous-phase toxicity test, to evaluate the toxicity of drilling fluids, including SBFs. Using the SPP toxicity test, SBFs have routinely been found to have low toxicity; however, an inter-laboratory variability study indicated that SPP toxicity results are highly variable when applied to SBFs (USEPA 2000). In general, benthic test organisms appear to be more sensitive to the SBFs than water-column organisms. The ranking for SBF toxicity from least toxic to most toxic is: esters < internal olefins < linear alpha olefins < polyalphaolefins < paraffins (USEPA 2000).

6.1.1.2 Chronic Effects

Few studies have evaluated impacts on Alaskan species following chronic exposure to drilling fluids; the species that have been tested are all invertebrates. The few chronic data are consistent, however, and indicate that chronic lethal toxicity is not likely to be more than some 20-fold greater than acute lethal toxicity; chronic sublethal toxicity appears to range from 3-fold to 75-fold greater than acute lethal toxicity, which is within the same range as chronic lethal effects. However, the chronic sublethal data are much more difficult to interpret, physiologically and ecologically. Sample sizes routinely are very small. Most importantly, observations that sublethal effects occur close to lethal effect levels miss the point; for most studies, changes were also noted at the lowest level tested. Thus, estimating No-Observable-Effect-Levels (NOELs) are not possible for much of the reported data (Tetra Tech 2006).

Laboratory studies on recruitment and development of benthic communities suggest that drilling fluid and barite can affect recruitment and alter benthic communities or depress abundances. These data are corroborated by results from artificial substrate experiments conducted in the Beaufort Sea; these showed significantly different colonization rates at drilling fluid test plots and control plots, especially for amphipods and copepods (Tetra Tech 2006).

The lowest reported concentration of drilling fluid producing a significant sublethal chronic effect was 50 mg/L for 30 days of continuous exposure with bay mussels, and there was no attempt to separate chemical from physical effects (USEPA 1985).

A laboratory study examined the chronic toxicity of cuttings from Beaufort Sea wells on the sand dollar (*Echinarachnius parma*) (Osborne and Leeder 1989). Exposure to mixtures as low as 10 percent cuttings and 90 percent sand were found to affect the survival of the benthic organisms, with 100 percent mortality occurring within 23 days in some test cases (Tetra Tech 2006).

6.1.2 Toxicity of Mineral and Diesel Oil

In the past, the oil industry has added diesel oil to drilling fluid systems to free stuck drilling pipes and for other specialized applications. Diesel oil is highly toxic to aquatic life, and much of the toxicity of drilling fluids has been attributed to its presence. Studies have found high correlations of toxicity with added diesel and mineral oil to whole fluid (diesel oil $r = 0.88$; mineral oil $r = 0.97$). Toxicity did not correlate quite as well with the oil levels determined in a variety of fluid samples ($r = 0.81$). The available data indicate that this may be partially due to various types of sequestrations within the drilling fluid matrix as well as the variable presence of toxic constituents in drilling fluids other than diesel or mineral oil (Tetra Tech 2006).

Because of the toxicity of diesel oil, EPA has prohibited its discharge in fluids and cuttings. Instead, EPA allows the use of mineral oils to free stuck pipes and the discharge of residual amounts of mineral oil pills, provided that the pill and a buffer of drilling fluid on either side of the pill are removed and not discharged. The residual mineral oil concentration in the discharged fluid should not exceed 2 percent (volume-volume [v/v]) and must comply with all previous permit conditions (Tetra Tech 2006).

Mineral oils differ from diesel oils in that they contain a lower concentration of aromatic hydrocarbons (15–20 percent vs. 20–61 percent for diesel oil). In addition, saturated aliphatics (paraffinics) generally represent a larger percentage of mineral oils compared to diesel oil. Aromatic hydrocarbons are generally more toxic and resist biodegradation to a greater degree than do paraffinics (Petrazzuolo 1983a). Research studies indicate that some mineral oils are much less acutely toxic (5 to 30 times less) to certain marine organisms than diesel oil (Tetra Tech 2006). Despite the reduced toxicity of some mineral oils as compared to diesel oils, mineral oils do contribute potentially toxic organic pollutants to drilling fluids to which they are added (Tetra Tech 2006).

The hazard to aquatic life from consuming organisms or inhabiting water contaminated with diesel oils is greater than that for mineral oil because the aromatics in diesel oils tend to be more soluble and biologically active than paraffinic hydrocarbons, although the PAHs contained in mineral oils have been shown to be highly soluble in adipose tissue and lipids (Sittig 1985). The hazards associated with residual mineral oil present in discharged fluid covered under the proposed permit is not expected to be significant (Tetra Tech 2006).

6.2 HUMAN HEALTH IMPACTS

In July 2009, the Agency for Toxic Substances and Disease Registry (ATSDR) published a Public Health Consultation which evaluated seafood and plant data collected from Cook Inlet near the Native Villages of Port Graham, Nanwalek, Seldovia, and Tyonek. The consultation was requested by these Native Villages to ATSDR to evaluate whether or not eating traditional subsistence foods could harm their health.

ATSDR reviewed seafood and plant data collected by the EPA as published in the 2003 *Survey of Chemical Contaminants in Fish, Invertebrates , and Plants Collected in the Vicinity Tyonek, Seldovia, Port Graham, and Nanwalek*; the ADEC as published in the 2005 *Fish Monitoring Study*, and three studies the Cook Inlet Regional Citizen's Advisory Council's (CIRCAC) conducted through their Environmental Monitoring Program in 1993, 1996 and 2000. Environmental data that had been collected during these studies and that ATSDR reviewed included, salmon and other saltwater fish, mussels, clams, snail, chiton (badarki), octopus, kelp, and goose tongue.

ATSDR reached five important conclusions in the health consultation and include:

ATSDR concluded that lead found in chiton (badarki) could harm children's health. Preschool and elementary-age children should only eat 3 ounces or less of chiton a week to help prevent high blood lead levels. Adults eating chiton are not at risk of high blood lead levels because adults absorb less lead from food than children. Further, ATSDR concluded that the small amount of lead found in other Native foods will not cause elevated blood lead levels in children or adults.

ATSDR concluded that other chemicals detected in Native foods from Cook Inlet and evaluated were not expected to harm people's health. While metals, pesticides, PCB's, one dioxin compound, and PAHs were detected in Native foods in small amounts, the levels were often at levels found in fish from other parts of Alaska and from grocery store bought fish.

Three additional conclusions ATSDR reached were, based on anticipated consumption rates obtained through community surveys, eating fish and other Native foods was not expected to cause a noticeable increase in cancer. Several chemicals that are known to cause cancer were infrequently detected or detected at low levels. Due to limited data available, the effects of eating eggs or organs from Cook

Inlet fish could not be determined, and, lastly, the effects from several PAHs that were detected in low levels due to limited information.

As discussed n the ATSDR Consultation, accurately estimating how much fish or Native foods are consumed can be difficult to obtain. Results can vary based on age, sex, lifestyle, traditional customs, or health status. Based on conversations with representatives of Port Graham, ATSDR used 7 oz. per day of fish, or about one fish meal per day.

In addition, to gain a more complete and accurate picture of the amount and quality of subsistence foods consumed by the Cook Inlet Tribes, the Seldovia Village Tribe is currently in the process of conducting a two phase subsistence consumption assessment for Cook Inlet Tribes. Funded by EPA through the Indian General Assistance Program (IGAP), the first phase has been completed and is currently being reviewed. The second phase will include testing and analysis of subsistence foods frequently consumed by tribal members which is scheduled to be conducted during 2013-2014.

6.3 Physical Effects of Discharge

Sanitary effluent from exploration drilling operations must meet the effluent limitations in the proposed Cook Inlet Exploration general permits for total suspended solids (TSS) of 30 to 56 mg/L, depending on the treatment unit used. Excess cement slurry may contain up to 200,000 mg/L of TSS (daily maximum). However, because this wastestream is intermittent and the volume is small (about 4,200 gallons per event), it is not predicted to cause adverse impacts to marine organisms (SAIC 2001).

Estimates of the annual suspended solids discharged from the municipalities (2.03 thousand tonnes), refinery (0.03 thousand tonnes), and drilling fluids and cuttings (0.93 thousand tonnes) in Cook Inlet are only a fraction of the suspended sediments (36,343 thousand tonnes) discharged by the Knik, Matanuska and Susitna rivers.

Dilution rates as high as 1,000,000:1 may occur for drilling solids within a radial distance of 200 meters (656 ft) or 0.13 km^2 (0.05 mi^2) of a platform with surface currents of 30-35 cm/s (about 0.6–0.7 knots) (National Research Council 1983). Tidal currents in lower Cook Inlet may have velocities of 102–153 cm/s (about 2–3 knots), or more. The currents associated with the Cook Inlet circulation regime, especially the strong tidal currents and the morphometry of the inlet produce considerable crosscurrents and turbulence in the water column during both ebb and flood tides. The cumulative effects of hydrodynamic processes suggest the water column in lower Cook Inlet generally is vertically well mixed. The similarities between the respective suspended particulate matter concentrations, salinities, and temperatures at the surface and near the bottom suggest not only vertical mixing but also show the cross-channel gradients that exist in the water column. These gradients indicate that dilution, rather than deposition, is the major process controlling suspended particulate matter concentrations in the central part of the inlet (MMS 2003).

Only part of the solids in the drilling fluids and cuttings discharged into Cook Inlet may accumulate on the seafloor near the discharge. The bottom currents in lower Cook Inlet are strong enough to prevent the deposition of sand-size and smaller particles (Sharma 1979; Hampton 1982). Regional sediments indicate sorting by present-day transporting currents (Hampton, et al. 1981). Silts and muds are moved southward to outermost Cook Inlet and Shelikof Strait (Sharma and Burrell 1970; Carlson et al. 1977; Hampton 1982; Boehm 2001).

The flow of Cook Inlet water generally is to the southwest. Discharged substances that are dissolved or remain in suspension generally would be transported out of Cook Inlet and into the Gulf of Alaska within about 10 months (Kinney et al. 1969, 1970). The density of any drilling fluids discharged into Cook Inlet should range within 1,000–2,000 ppt wet weight. This is a typical density range for used drilling fluid. For example, Adams (1985) stated a range between 1,080 and 1,800 ppt and the National Research Council (1983) a range (for OCS wells) of 1,190–2,090 ppt (MMS 2003).

With a dilution rate of 10,000:1, the concentration of drilling fluid initially would be reduced to 0.10–0.20 ppt (100–200 ppm) within 100 m (328 ft) of the discharge site; a dilution rate of 1,000,000:1 would reduce the concentrations to 0.001–0.002 ppt (1–2 ppm) within 200 m (656 ft) of the discharge site. Rapid settling of the heavier particles would result in greater reductions in the concentrations of the drilling fluids inside 100–200 m (328 – 656 ft) from discharge than were estimated by using only the dilution factors. The concentration of suspended particulate matter in the water column of lower Cook Inlet ranges from 1–50 ppm. Thus, within about 100–200 m (328 – 656 ft) of the discharge site, the concentration of particulate matter in the fluids and cuttings discharged into the water column is expected to be reduced to levels comparable to the levels of naturally occurring suspended-particulate matter (MMS 2003).

EPA has determined that drilling discharges associated with short-term exploration operations would have little effect on the environment due to deposition of drilling-related materials on the seafloor.

6.4 SUMMARY

6.4.1 Lower Trophic Level Organisms

Routine, anticipated activities during exploration in Cook Inlet probably would not have measurable effects on local populations of lower trophic-level organisms (MMS 2003).

EPA estimates the potential drilling of up to 12 exploration and delineation wells in federal waters and up to 20 exploration and delineation wells in state waters during the 5-year term of the permits (BOEM 2012). The total volume of drilling fluids estimated to be discharged during the 5-year permit term is 360,000 bbls. The total mass of cuttings estimated to be discharged during the 5-year permit term is 420,000 bbls. These amounts of material are a fraction of the particulate matter that rivers discharge daily into Cook Inlet. Discharges would become diluted rapidly as high as 1,000,000:1 with a distance of 200 m (656 ft) of a platform, and there would be no effect on planktonic organisms, such as shrimp (National Research Council 1983). The drilling fluids and cuttings that accumulate on the seafloor in relatively shallow water might affect some benthic organisms for a short period close to the discharge point (MMS 1995). This assessment confirms the conclusion that the effect probably would be sublethal for adults and might be lethal for immature stages within 1,000 meters of jack-up rigs that were actively discharging (i.e., for a few months or about a generation for typical benthic organisms) drilling fluids and cuttings. This assessment also confirms the conclusion in the water quality section that mixing in the water column would reduce the toxicity of drilling fluids to levels that would not be harmful to organisms in the water column.

In summary, the routine activities associated with exploration in upper Cook Inlet have not had a documented effect on lower trophic-level organisms. It is expected that the routine activities associated with exploration in the future would be similar, and no measurable effects on the local populations are expected from these routine activities (MMS 2003).

6.4.2 Fish

Fisheries resources (i.e., pelagic finfish, ground finfish, and shellfish) in the lower Cook Inlet area are described in Section 6. MMS performed an analysis on population-level impacts; its definition of a population is defined as a group of organisms of one species occupying a defined area (the central Gulf of Alaska encompassing the South Alaskan Peninsula, Kodiak Archipelago, Shelikof Strait, Cook Inlet, and Prince William Sound) and usually isolated to some degree from other similar groups. Routine activities associated with this alternative that may adversely affect fisheries resources include permitted drilling discharges. It is not expected that the various effects to fisheries resources, taken altogether, would cause population-level changes in the central Gulf of Alaska (MMS 2003).

6.4.3 Marine Birds

Platform discharges are not expected to have an effect on marine and coastal birds because of the high degree of dilution that would occur and the fact that bioaccumulation of associated pollutants is not expected (SAIC 2000).

The risk of a spill exists any time crude oil or petroleum products are handled. Oil spills associated with the exploration of crude oil may occur from well blowouts. Petroleum activities may also generate chronic low volume spills involving fuels and other petroleum products associated with normal operation of drilling rigs and vessels. Spills may also be associated with the transportation of refined products to provide fuel for generators, marine vessels, and other vehicles used in exploration and development activities. A worst case oil discharge from an exploration facility is restricted by the maximum tank or vessel storage capacity or by a well's ability to produce oil. Spills occurring at exploration facilities are usually related to everyday operations, such as fuel transfers (ADNR 2009). Since 1999, there have been 18 crude oil spills of 100 gallons or more from pipelines, platforms, onshore production facilities, storage facilities, and marine tankers in the Cook Inlet area. Six of these were more than 500 gallons (ADEC 2008).

Risk of effects from a spill can be avoided, minimized, and mitigated through preventive measures, monitoring, and rigorous response capability (ADNR 2009). Federal regulations at 40 CFR § 112 and Alaska Statute (AS) 46.04.030 provide that no person may operate an exploration facility unless the operator is in compliance with an oil discharge prevention and contingency plan. The contingency plan must address the existing and proposed means of oil discharge detection, such as surveillance schedules, leak detection, monitoring systems, and spill-detection instrumentation.

6.4.4 Marine Mammals

Seven species of nonendangered marine mammals numbering in the hundreds to thousands commonly occur year-round or seasonally in a portion of or throughout the Cook Inlet Planning Area and could be exposed to some OCS exploration activities in Cook Inlet. These include the harbor seals and northern fur seals; Southcentral Alaska sea otters; killer, minke, and gray whales; and Dall's and harbor porpoises. Pollution and alteration of habitats could adversely affect these marine mammals found within Cook Inlet.

In the subsections below, it should be noted that the term *regional population or population within the region* is defined as the number of animals of a species that occur seasonally or year-round within the Cook Inlet Planning Area. A portion of a population in the region, for example, would be the number of harbor seals occurring in Kamishak Bay during the spring-summer breeding and molting periods (MMS 2003).

6.4.4.1 Effectiveness of Mitigating Measures

The stipulation on Protection of Biological Resources primarily concerns protection of benthic habitats that may be buried or covered by jack-up rig installation. The amount of benthic habitats (probability 1 square kilometer [km^2] or 0.386 square mile [mi^2]) is not expected to be of consequence to most nonendangered marine mammal populations, with the possible exception of gray whales that may feed in the area; thus, this stipulation is not expected to provide much additional protection to nonendangered marine mammals (MMS 2003).

6.4.5 Human Health

Increases in metal body burdens of animals consumed by humans that are attributable to drilling fluid discharges are expected to be minor. The proposed Cook Inlet Exploration general permits will ensure increased compliance with oil and grease effluent limitations through the water sheen monitoring requirement that is performed once per day when discharging, during conditions when observation of a sheen on the surface of the receiving water is possible in the vicinity of the discharge, and when the facility is manned. Also most contaminants detected in Cook Inlet fish are less than or comparable to contaminants detected in regional or national studies. Because of these reasons above and because additional permitted discharges are minimally toxic, adverse human health effects are unlikely to result from Cook Inlet exploration discharges. Metal content of drilling fluids should be minimized through adherence to the effluent limitations in the proposed Cook Inlet Exploration general permits to decrease the amount of heavy metals discharged to Cook Inlet (Tetra Tech 2006).

6.5 COASTAL ZONE MANAGEMENT

The Alaska Coastal Management Program (ACMP) was approved by NOAA in 1979 as a voluntary state partner in the National Coastal Management Program. The ACMP expired by operation of AS 44.66.020 and 44.66.030 on June 30, 2011. As a result of its expiration, the ACMP was withdrawn from this program on July 1, 2011, and there is no longer a Coastal Zone Management Act (CZMA) program in

Alaska (76 FR 39857). A statewide referendum to reinstate the ACMP failed on August 28, 2012 (Ballot Pedia 2012).

Because a federally approved coastal management program must be administered by a state agency, no other entity may develop or implement a federally approved coastal management program for the state. Accordingly, the CZMA Federal consistency provision no longer applies in Alaska. Federal agencies shall no longer provide the State of Alaska with CZMA Consistency Determinations or Negative Determinations pursuant to 16 U.S.C. 1456(c)(1) and (2), and 15 CFR part 930, subpart C.

6.6 MARINE WATER QUALITY

This section addresses compliance of Cook Inlet oil and gas exploration facility discharges with federal technology-based limits, State of Alaska Water Quality Standards (18 Alaska Administrative Code [AAC] 70), and Federal Ocean Discharge Criteria.

6.6.1 Technology-based Limits

Technology-based limits required under the Effluent Limit Guidelines (ELGs) are contained in the proposed Cook Inlet Exploration general permits. The ELGs established BCT, BAT, BPT, and NSPS for the Offshore and Coastal Subcategories of the Oil and Gas Extraction Point Source Category (40 CFR Part 435, Subparts A and D). This section describes the associated limitations and monitoring requirements for the individual wastestreams authorized by the proposed Cook Inlet Exploration general permits.

6.6.1.1 Drilling Fluids

The following limits and prohibitions are based on the ELGs: (1) no discharge of free oil; (2) no discharge of diesel oil; (3) a toxicity limit of 3 percent by volume. The proposed Cook Inlet Exploration general permits limit the discharge of organic contaminants through these free oil and diesel oil prohibitions, and by restricting the use of mineral oil in drilling fluids. Permittees must measure free oil in drilling fluid discharges using the static sheen test method, as described in the permits. Permittees must measure toxicity using a 96-hour LC_{50} on the SPP using the *Mysidopsis bahia* species.

Stock barite, which is added to drilling fluids, contains cadmium and mercury and is the main source of heavy metals in drilling fluid discharges. Pursuant to the ELGs, the proposed Cook Inlet Exploration general permits establish effluent limitations for cadmium and mercury of 3 mg/kg and 1 mg/kg, respectively. The proposed Cook Inlet Exploration general permits will require permittees to report cadmium and mercury concentrations measured in the stock barite before it is added to the drilling fluids using USEPA Test Methods 245.5 or 7471. The technology-based limits for cadmium and mercury are surrogate parameters for other metals contained in the barite.

The proposed Cook Inlet Exploration general permits prohibit discharges of oil-based drilling fluids, inverse emulsion drilling fluids, oil-contaminated drilling fluids, and drilling fluids to which mineral oil has been added. The purpose of these prohibitions is to ensure compliance with the toxicity limit and the prohibition against the discharge of free oil. The proposed Cook Inlet Exploration general permits allow an exception to those prohibitions for drilling fluids to which mineral oil or nonaqueous-based fluids have been added as a carrier agent, lubricity additive, or pill.

The proposed Cook Inlet Exploration general permits prohibit discharges of nonaqueous based drilling fluids. In territorial seas and federal waters, however, permittees are authorized to discharge nonaqueous-based and synthetic-based drilling fluids that adhere to drill cuttings, pursuant to the Offshore Category ELGs, as amended in 2001.

6.6.1.2 Drill Cuttings

The main source of pollutants in drill cutting discharges come from drilling fluids that are used in drilling a well that then adhere to the drill cuttings. Therefore, on the basis of the ELGs for BAT, BCT, BPT, and NSPS, drill cuttings discharges are subject to the same limits that apply to drilling fluid discharges as described in the proposed Cook Inlet Exploration general permit fact sheets.

As noted above, in territorial seas and federal waters, the proposed Cook Inlet Exploration general permits would authorize the discharge of drill cuttings generated using synthetic-based drilling fluids. The use of synthetic-based fluids is a type of pollution prevention technology because the drilling fluids are not disposed of through bulk discharge at the end of drilling. Instead, the drilling fluids are brought back to shore and refurbished so they can be reused. In addition, drilling with synthetic-based fluids allows operators to drill a slimmer well and causes less sloughing of the well during drilling than when water-based fluids are used, reducing the volume of drill cuttings that are discharged. The proposed Cook Inlet Exploration general permits require permittees to remove synthetic-based drilling fluids from the drill cuttings prior to discharge, which is not required when water-based fluids are used.

The ELGs also include limits for sediment toxicity and biodegradation. Although the ELGs do not address specific types of synthetic-based fluids, the ELGs contain toxicity and biodegradation limits that require operators to use less toxic fluids that biodegrade quickly.

The proposed Cook Inlet Exploration general permits contain limits for synthetic-based fluids at three points. First, for stock synthetic fluids prior to combination with other components of the drilling fluids system, the proposed Cook Inlet Exploration general permits impose limits on polynuclear aromatic hydrocarbons (PAHs), sediment toxicity (10-day), and biodegradation rate. Second, combined fluid components are limited for formation oil contamination. Third, drilling fluids that adhere to drill cuttings are limited for sediment toxicity (4-day), and formation oil contamination.

6.6.1.3 Deck Drainage

For deck drainage discharges, the Offshore and Coastal Subcategory ELGs for NSPS, BAT, and BCT require a limitation of no discharge of free oil as determined by the presence of film, sheen, or a discoloration of the surface of the receiving water. This limit was contained in the 2007 NPDES general permit and has been retained in the proposed Cook Inlet Exploration general permits.

6.6.1.4 Sanitary Wastewater

For sanitary waste discharges, the Offshore and Coastal Subcategory ELGs for NSPS and BCT require total residual chlorine to be maintained as close to 1 mg/L as possible for facilities that are continuously manned by 10 or more persons. The ELGs also require no discharge of floating solids for offshore facilities that are continuously manned by nine or fewer persons or intermittently manned by any number of persons. These limits were contained in the 2007 NPDES general permit and are retained in the proposed Cook Inlet Exploration general permits.

6.6.1.5 Domestic Wastewater

For domestic waste discharges, the ELGs prohibit the discharge of floating solids, garbage, or foam and require compliance with 33 CFR Part 151. This limit was contained in the 2007 NPDES general permit and has been retained in the proposed Cook Inlet Exploration general permits.

6.6.1.6 Chemically-Treated Sea Water and Fresh Water Discharges

The proposed Cook Inlet Exploration general permits use generic BPJ-based limits, on the basis of available technology, to regulate chemically treated sea water and fresh water discharges, rather than attempting to limit the discharge of specific biocides, scale inhibitors, and corrosion inhibitors. Due to the large number of chemical additives used, it would be very difficult to develop technology-based limits for each individual additive. In addition, if the proposed Cook Inlet Exploration general permits were to limit specific chemicals, it could potentially halt the development and use of new and potentially more beneficial treatment chemicals.

Many of the chemicals normally added to sea water or fresh water, especially biocides, have manufacturer's recommended maximum concentrations or EPA product registration labeling. In addition, information obtained from offshore operators demonstrates that it is unnecessary to use any of the chemical additives or biocides in concentrations greater than 500 mg/L as described in the proposed Cook Inlet Exploration general permit fact sheets. Therefore, the proposed Cook Inlet Exploration general permits limit discharges of sea water or fresh water to the most stringent of the following:

- The maximum concentrations and any other conditions specified in the EPA product registration labeling if the chemical additive is an EPA-registered product;
- The maximum manufacturer's recommended concentration; or
- 500 mg/L

Compliance with this limit is calculated on the basis of the amount of treatment chemicals added to the volume of water discharged.

As with other miscellaneous discharges described above, the proposed Cook Inlet Exploration general permits contain BCT limits prohibiting the discharge of free oil for chemically treated sea water and fresh water discharges. Free oil is a direct measurement of oil contamination and, on the basis of BPJ, the proposed Cook Inlet Exploration general permits uses it as a surrogate parameter for conventional pollutants in these discharges.

6.6.1.7 All Discharges

The proposed Cook Inlet Exploration general permits prohibit the discharge of rubbish, trash, and other refuse on the basis of the International Convention for the Prevention of Pollution from Ships (MARPOL). On the basis of CWA § 403(c), 33 USC § 1343(c), the proposed Cook Inlet Exploration general permits also requires minimization of the discharge of surfactants, dispersants, and detergents.

6.6.2 Water Quality-Based Permit Conditions

The proposed Cook Inlet Exploration general permits establish water quality-based limitations and monitoring requirements necessary to ensure that the authorized discharges comply with the CWA's Ocean Discharge Criteria and State Water Quality Standards, for those waters in which they apply (see Section 1.2.1 of this ODCE).

6.6.2.1 Ocean Discharge Criteria

Discharges to marine waters are subject to additional regulatory requirements established under CWA §403. CWA § 403 applies to marine discharges under NPDES permits and allows for more stringent controls when necessary to protect the environment. It is not restricted by engineering attainability, nor is it limited by rigorous cost or economic restrictions when determining permit conditions. It includes consideration of sediment; as well as water column effects. It not only protects aquatic species but also places special emphasis on unique, sensitive, or ecologically critical species. EPA or an NPDES-authorized State like Alaska can impose discharge limitations or other conditions needed to attain compliance with CWA § 403.

Based on the Ocean Discharge Criteria, the Draft Permit retains discharge rate and depth limits for drilling fluids discharges, as well as discharge prohibitions in several environmentally sensitive areas of Cook Inlet. The 2007 Permit established toxicity triggers for sea water and fresh water discharges to which treatment chemicals have been added. The proposed Cook Inlet Exploration general permits retain all of these requirements.

6.6.2.2 State Water Quality Standards

CWA § 301(b)(1)(C), 33 USC § 1311(b)(1)(C), and 40 CFR section 122.44(d)(1) require CWA § 402 permits issued within State waters to contain the limitations and conditions that are necessary to attain State Water Quality Standards.

Treatment chemicals such as biocides, corrosion inhibitors, and oxygen scavengers are used in a number of discharges such as cooling water. Many of those chemical additives are highly toxic, which was an issue raised by tribal members during the Traditional Ecological Knowledge interview process described during the 2007 NPDES general permit process. To ensure that these discharges comply with both State Water Quality Standards and Ocean Discharge Criteria, the proposed Cook Inlet Exploration general permits retain whole effluent toxicity triggers.

Alaska marine water quality standards for the protection of aquatic life (18 AAC 70) (ADEC 2003) include the following:

- Temperature: Discharges may not cause the weekly average temperature to increase more than 1°C (34°F). The maximum rate of change may not exceed 0.5°C per hour. Normal daily temperature cycles may not be altered in amplitude or frequency.
- Dissolved Inorganic Substances: Discharges may not increase the natural salinity by more than 4 parts per thousand (ppt) for waters with natural salinity between 13.5 and 35.0 ppt (as in the Forelands area of Cook Inlet).
- Sediment: Discharges may not cause a measureable increase in concentration of settleable solids above natural conditions, as measured by the volumetric Imhoff cone method.
- Toxics and Other Deleterious Organic and Inorganic Substances: Individual substances in the discharges may not exceed the criteria in Table IV and Table V, column B in the *Alaska Water Quality Criteria for Toxic and Other Deleterious Organic and Inorganic Substances*, May 2003, or any chronic or acute criteria established in 18 AAC 70, for a toxic pollutant of concern, to protect sensitive and biologically important life stages of resident species of Alaska. There may be no concentrations of toxic substances in water or in shoreline or bottom sediments, that, singly or in combination, cause, or reasonably can be expected to cause, toxic effects on aquatic life or produce undesirable or nuisance aquatic life, except as authorized in 18 AAC 70. Substances may not be present in concentrations that individually or in combination impart undesirable odor or taste to fish or other aquatic organisms, as determined by either bioassay or organoleptic tests.
- Color: Color or apparent color may not reduce the depth of the compensation point for photosynthetic activity by more than 10 percent from the seasonally established norm for aquatic life. For all waters without a seasonally established nor for aquatic life, color or apparent color may not exceed 50 color units or the natural condition, whichever is greater.
- Petroleum Hydrocarbons, Oil and Grease: Total aqueous hydrocarbons in the water column may not exceed 15 µg/L. Total aromatic hydrocarbons in the water column may not exceed 10 µg /L. There may be no concentrations of petroleum hydrocarbons, animal fats, or vegetable oils in shoreline or bottom sediments that cause deleterious effects to aquatic life. Surface waters and adjoining shorelines must be virtually free from floating oil, film, sheen, or discoloration.
- Radioactivity: The discharges may not exceed the concentration specified in the Alaska Drinking Water Standards (18 AAC 80).
- Residues: The discharges may not, alone, or in combination with other substances or wastes, make the water unfit or unsafe for use, or cause acute or chronic problem levels as determined by bioassay or other appropriate methods. The discharges may not, alone or in combination with other substances, cause a film, sheen, or discoloration on the surface of the water or adjoining shorelines; cause leaching of toxic or deleterious substances; or cause a sludge, solid, or emulsion to be deposited beneath or upon the surface of the water, within the water column, on the bottom, or upon adjoining shorelines.

6.6.2.3 Mixing Zones and State Water Quality Standards

Mixing zones are established by states and EPA to specify a limited portion of a waterbody in which otherwise applicable water quality criteria may be exceeded. In the coastal waters and territorial seas, states have the authority to define mixing zones and determine their sizes. In territorial seas, the Ocean

Discharge Criteria concurrently apply and can restrict mixing zone sizes. In federal waters, state standards do not apply; thus, mixing zones are governed solely by the Ocean Discharge Criteria as described in EPA's proposed Cook Inlet Exploration general permit fact sheet.

When authorized by ADEC, the State Water Quality Standards require mixing zones to be as small as practicable (18 AAC 70.240). In determining whether to use a mixing zone, 18 AAC 70.245 requires full protection of the existing uses of the waterbody. Within a mixing zone, State Water Quality Standards allow water quality criteria for chronic aquatic life and human health protection to be exceeded as long as water quality criteria are met outside the mixing zone. Some water quality standards, however, require that acute aquatic life criteria are met at a boundary of a smaller zone of initial dilution established within the mixing zone (18 AAC 70.255). ADEC has determined that the discharges authorized by the 2007 NPDES general permit are not likely to persist in the environment and, therefore, has authorized mixing zones as described in their proposed general permit fact sheet.

6.6.2.4 Mixing Zones and Ocean Discharge Criteria

The ocean discharge criteria at 40 CFR § 125.121(c) allows a mixing zone extending laterally 100 meters in all directions from the discharge point(s) or to the boundary of the zone of initial dilution as calculated by a plume model approved by the director, whichever is greater, unless the director determines that the more restrictive mixing zone or another definition of the mixing zone is more appropriate. For the proposed Cook Inlet general permits, EPA and DEC have decided to utilize a 100 m mixing zone for sanitary wastewater discharges and chemically treated seawater. As more facilities utilize the general permits, more information will become available in order to determine whether the mixing zone should be more or less restrictive or whether mixing zones should be redefined. Any new determination could be incorporated into a future permitting action.

6.6.2.5 Chemically Treated Sea Water Discharges

The proposed Cook Inlet Exploration general permits include new water quality-based limits for miscellaneous discharges to which treatment chemicals, such as biocides, are added. Whole effluent toxicity triggers in the proposed Cook Inlet Exploration general permits are based on the effluent concentration at the edge of the mixing zone. The proposed Cook Inlet Exploration general permits contain whole effluent toxicity and free oil requirements because they are necessary to meet state water quality standards and Ocean Discharge Criteria.

Operators will be able to use treatment chemicals that are most efficient for their operations as long as they enable the facility to consistently meet effluent limits. While this approach will ensure the protection for water quality, it will also provide maximum flexibility for operators to switch to newer products that may become available. Therefore, to ensure flexibility, the proposed Cook Inlet Exploration general permits do not prescribe specific chemical additives that may be used.

6.6.2.6 Toxicity Triggers

As calculated, the toxicity triggers compel dischargers to investigate the composition of the discharge when concentrations that may result in chronic toxicity at the edge of a 100-meter mixing zone reach a certain level. This will result in changes that ensure compliance with State Water Quality Standards (18

AAC 70.030), which states that "[a]n effluent discharges to a water may not impart chronic toxicity to aquatic organisms."

Because discharges less than 10,000 gallons per day will be very dilute and are not likely to exhibit toxic effects at the edge of the mixing zone, toxicity triggers are not proposed for these discharges. The proposed Cook Inlet Exploration general permits include a table so that operators can obtain their toxicity effluent triggers according to their discharge rate.

6.6.2.7 Free Oil Limitations

The proposed Cook Inlet Exploration general permits limit the discharge of free oil to help prevent the discharge of toxic pollutants contained in oil. The Ocean Discharge Criteria include 10 factors that must be considered in determining whether a discharge will cause unreasonable degradation of the marine environment (40 CFR 125.122). One of the 10 factors is the potential impact on human health through direct and indirect pathways. 40 CFR 110.3 defines quantities of oil that may be harmful to public health or welfare as a discharge that causes a sheen or discoloration on the receiving water. Therefore, the proposed Cook Inlet Exploration general permits limit chemically treated sea water discharges to no free oil as measured using the visual sheen test method, as described in the permits.

6.6.2.8 Sanitary Waste Discharges

The proposed Cook Inlet Exploration general permits includes the same water-quality based limitations for BOD and TSS as the 2007 NPDES general permit for facilities in coastal waters and the territorial seas.

As required by 40 CFR 435, the 2007 NPDES general permit limits the total residual chlorine concentration to a minimum of 1 mg/L throughout the area of coverage. The 2007 NPDES general permit also has a daily maximum limitation for total residual chlorine of 19 mg/L, which applies to facilities in coastal waters and the territorial seas. The proposed Cook Inlet Exploration general permits require effluent concentrations at the edge of the mixing zone to meet a more stringent limit 7 mg/L to meet the State Water Quality Standard of 7 µg/L with an effluent dilution of 0.1 percent. EPA expects that most permittees will install dechlorination equipment to meet this new effluent limit as described in the proposed Cook Inlet Exploration general permits fact sheets.

6.6.2.9 Summary

The volume and concentrations of pollutants in the discharges from oil and gas facilities in Cook Inlet covered under the proposed Cook Inlet Exploration general permits are expected to meet human health water quality criteria at the end-of-pipe, as well as water quality criteria for the protection of aquatic life. Therefore, there is little potential for discharges to exceed marine water quality criteria.

6.7 DETERMINATION OF UNREASONABLE DEGRADATION

Under the Ocean Discharge Criteria, a CWA § 402 permit may be issued if a determination that a discharge will not cause unreasonable degradation to the marine environment can be made. If insufficient information exists to make such a determination prior to permit issuance, the permit may be issued only if the discharge will not cause irreparable harm to the marine environment while additional monitoring is undertaken, and if there are no reasonable alternatives to onsite disposal.

On the basis of the Ocean Discharge Criteria, the 2007 NPDES general permit established discharge rate and depth limits for drilling fluids discharges, toxicity triggers for sea water and fresh water discharges to which treatment chemicals have been added as well as discharge prohibitions in several environmentally sensitive areas of Cook Inlet. The proposed Cook Inlet Exploration general permits retain these requirements.

EPA and DEC have determined that discharges authorized from the proposed Cook Inlet Exploration general permits will not cause unreasonable degradation as long as the proposed Cook Inlet Exploration general permit's limitations, depth-related conditions, and environmental monitoring requirements are met.

6.7.1 CRITERION 1

The quantities, composition, and potential for bioaccumulation or persistence of the pollutants to be discharged:

- Approximately 84,000 bbl of drilling fluids and 98,000 barrels of drill cuttings would be discharged *each year* from oil and gas exploration and development drilling operations in Cook Inlet during the 5-year permit term (assuming a total of 14 wells in the ODCE area).
- Due to the low volume and/or minimal pollutant concentrations of the remaining discharges, the potential for bioaccumulation or persistence of contaminants is low.
- Discharges from exploration drilling operations are expected to meet the appropriate effluent limitation requirements listed in the proposed Cook Inlet Exploration general permits as well as the appropriate Alaska Water Quality Standards in 18 AAC 70.

6.7.2 CRITERION 2

The potential transport of such pollutants by biological, physical, or chemical processes:

- Cook Inlet is a high-energy environment. Fast tidal currents and tremendous mixing produce rapid dispersion of soluble and particulate pollutants.
- Within a distance of between 100 and 200 m (328 – 656 ft) from the discharge point, the turbidity caused by suspended particulate matter in discharged fluids and cuttings is expected to be diluted to levels that are within the range associated with the variability of naturally occurring suspended particulate matter concentrations.
- In general, the amounts of additives in the other discharges are expected to be relatively small (from 400 to 800 liters per month) and diluted with sea water several hundred to several thousand times before being discharged into the receiving waters.

6.7.3 CRITERION 3

The composition and vulnerability of the biological communities that may be exposed to such pollutants, including the presence of unique species or communities of species, the presence of

species identified as endangered or threatened pursuant to the Endangered Species Act, or the presence of those species critical to the structure or function of the ecosystem, such as those important for the food chain:

- Low concentrations of BOD and nutrients in sanitary waste discharges could stimulate primary productivity and enhance zooplankton production. This effect is predicted to be negligible.

- Threatened and endangered species that could occur in Cook Inlet include short-tailed albatross, Steller's eider, Kittlitz Murrelet, blue whale, fin whale, humpback whale, northern right whale, Sei whale, sperm whale, Steller sea lion, beluga whale, and northern sea otter. Most of these species are not likely to use water close to permitted activities or are unlikely to inhabit Cook Inlet waters; they are unlikely to be affected by discharges from oil and gas exploration facilities in Cook Inlet.

- The Steller sea lion has designated critical habitat within the geographic area of coverage for the proposed Cook Inlet Exploration general permits but critical habitat restrictions do not allow discharges in the vicinity of Steller sea lions. In addition, rapid dilution and low toxicity of drilling fluids discharged to Cook Inlet imply that these discharges would not be likely to adversely affect pollock or other Steller sea lion prey. Pollutant concentrations in mixing zones complying with chronic water standards are not expected to adversely affect Steller sea lions in Cook Inlet.

- Drilling fluid discharges in Cook Inlet could alter prey available to the northern sea otter in the immediate vicinity of the discharges through burial of benthic organisms or changing bottom habitat characteristics. Exposure to pollutants within mixing zones and exposure to discharged water complying with chronic water standards is not expected to adversely affect northern sea otters.

- Beluga whales have been identified as depleted under the Marine Mammal Protection Act and endangered under the ESA. Drilling fluid discharges in Cook Inlet could adversely affect prey availability in the immediate vicinity of the discharges because of the burial of benthic organisms, or changes in bottom habitat characteristics, but such effects would be of limited size and duration. The discharges authorized under the proposed Cook Inlet Exploration general permits may affect individual beluga whales either directly or indirectly; however, *[This preliminary draft ODCE does not contain a determination at this time. The draft ODCE will contain more information on this issue]*

6.7.4 CRITERION 4

The importance of the receiving water area to the surrounding biological community, including the presence of spawning sites, nursery/forage areas, migratory pathways, or areas necessary for other functions or critical stages in the life cycle of an organism:

- Anadromous fish migrate through Cook Inlet towards spawning habitat in rivers and streams, and juveniles travel through Cook Inlet toward marine feeding areas. Habitats of potential concern (HPCs) within essential fish habitat (EFH) in Cook Inlet are the estuarine and nearshore habitats of Pacific salmon (e.g., eelgrass [*Zostera* sp.] beds) and herring spawning grounds (e.g., rockweed [*Fucus* sp.] and eelgrass). Offshore HPCs include areas with substrates that serve as cover for organisms including groundfish. All anadromous streams qualify as HPC. The Susitna River drainage is a primary source of these anadromous fish in Cook Inlet. Eulachon also return to spawn in some of the rivers. Because the waste discharges will be rapidly dispersed, it is unlikely that they would adversely affect migrating anadromous fish.

- Cook Inlet is an important area for marine mammals including beluga whales, Steller sea lions, and harbor seals. No adverse impacts from the waste discharges from the oil and gas exploration facilities in Cook Inlet are predicted.
- Lower Cook Inlet is one of the most productive areas for seabirds in Alaska, with an estimated 100,000 seabirds; 18 species breed in Cook Inlet.
- Waterbirds and waterfowl breed in the Cook Inlet region. In spring, large numbers of waterbirds migrate through the area. Large populations of staging waterfowl are found in tidal flats, along river mouths, and in bays on the west side of the inlet, including Redoubt Bay. Redoubt Bay has especially high concentrations of geese and ducks.
- Due to the injection of waste streams or rapid dispersion of waste discharges from the oil and gas exploration facilities in Cook Inlet, no adverse impacts on birds are predicted.

6.7.5 CRITERION 5

The existence of special aquatic sites including, but not limited to, marine sanctuaries and refuges, parks, national and historic monuments, national seashores, wilderness areas, and coral reefs:

- The following SGRs, Critical Habitat Areas CHAs, National Park, or SGS are in proximity to the proposed Cook Inlet Exploration general permits coverage areas:
  - Kachemak Bay CHA
  - Kalgin Island CHA
  - Lake Clark National Park
  - Susitna Flats SGR
  - Clam Gulch CHA
  - Trading Bay SGR
  - Redoubt Bay CHA
- Facilities within these areas would not be authorized under the proposed Cook Inlet Exploration general permits.

6.7.6 CRITERION 6

The potential impacts on human health through direct and indirect pathways:

- There is no known direct exposure pathway to humans from the discharges associated with oil and gas exploration in Alaska; indirect exposure is primarily from consumption of species exposed to discharges.
- Increases in metal body burdens of animals consumed by humans that are attributable to drilling fluid discharges are expected to be minor, but metal content of drilling fluids and other discharges from oil and gas exploration facilities should be minimized through adherence to the effluent limitations in the proposed Cook Inlet Exploration general permits to decrease the amount of heavy metals discharged to Cook Inlet.

- Most contaminants detected in Cook Inlet fish are less than or comparable to contaminants detected in regional or national studies.

6.7.7 CRITERION 7

Existing or potential recreational and commercial fishing, including finfishing and shellfishing:

- The routine activities associated with exploration in the area covered by the proposed Cook Inlet Exploration general permits are predicted to have insignificant impacts on the quantity or quality of the commercial, recreational, or subsistence harvests in Cook Inlet on the basis of the potential effects of disturbance on subsistence resources, the mobility of harvested species, the potential effects of permitted discharges on water quality, and the rapid dilution of discharges by the strong tidal flux of Cook Inlet.

6.7.8 CRITERION 8

Any applicable requirements of an approved Coastal Zone Management Plan:

- The Alaska Coastal Management Program (ACMP) expired on June 30, 2011 by operation of AS 44.66.020 and 44.66.030. As of July 1, 2011, there is no longer a CZMA program in Alaska. Because a federally approved CZMA program must be administered by a state, NOAA withdrew the ACMP from the National Coastal Management Program. See 76 Fed. Reg. 39,857 (July 7, 2011). As a result, the CZMA consistency provisions at 16 USC § 1456(c)(3) and 15 CFR Part 930 no longer apply in Alaska. Accordingly, federal agencies are no longer required to provide the State of Alaska with CZMA consistency determinations.

6.7.9 CRITERION 9

Such other factors relating to the effects of the discharge as may be appropriate:

No other factors have been identified relating to the effects of the discharge.

6.7.10 CRITERION 10

Marine water quality criteria developed pursuant to Section 304:

- The discharges from permitted oil and gas exploration facilities in Cook Inlet are expected to comply with all applicable marine water quality criteria.

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8.0 ACRONYMS AND ABBREVIATIONS

ACC	Alaska Coastal Current
AMSA	Area Meriting Special Attention
AOGCC	Alaska Oil and Gas Conservation Commission
APDES	Alaska Pollutant Discharge Elimination System
API	American Petroleum Institute
BAT	Best Available Technology Economically Achievable
BCT	Best Conventional Pollutant Control Technology
BOEM	Bureau of Ocean Energy Management
BOD	Biochemical oxygen demand
BPJ	Best Professional Judgment
BPT	Best Practicable Control technology Currently Available
BSEE	Bureau of Safety and Environmental Enforcement
CFR	Code of Federal Regulations
CHA	Critical Habitat Area
COD	chemical oxygen demand
CWA	Clean Water Act
DEC	Alaska Department of Environmental Conservation
DEIS	Draft environmental impact statement
EEZ	Exclusive Economic Zone
EFH	Essential fish habitat
ELG	Effluent limitation guidelines
ESA	Endangered Species Act
FMP	Fisheries management plan
FR	Federal Register
GC/MS	Gas Chromatography/Mass Spectrometry
LC50	Lethal concentration to 50% of test organisms
MLLW	Mean lower low water
MMS	Minerals Management Service
Mw	Moment magnitude
MSD	Marine sanitation device
NSPS	New Source Performance Standards
NMFS	National Marine Fisheries Service
NOI	Notice of intent
NPDES	National Pollutant Discharge Elimination System

OCS	Outer Continental Shelf
ODCE	Ocean Discharge Criteria Evaluation
OOC	Offshore Operators Committee
PAH	Polynuclear Aromatic Hydrocarbons
RFI	Request for Information
SGR	State Game Refuge
SGS	State Game Sanctuary
SPP	Suspended particulate phase
TOC	Total Organic Carbon
TSS	Total suspended solids
UOD	Ultimate oxygen demand
USEPA	United States Environmental Protection Agency
WBF	Water-based drilling fluid

UNITS

µg/g	micrograms per gram
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
µm	micrometers
°C	degrees Celsius
°F	degrees Fahrenheit
bbl	barrels
bbl/day	barrels per day
bbl/h	barrels per hour
bbl/well	barrels per well
cm	centimeters
cm/s	centimeters per second
colonies/100 mL	colonies per 100 milliliters
fm	fathoms
ft	feet
ft^3	cubic feet
ft/mi	feet per mile
ft/s	feet per second
g	grams
gal	gallons
g/day	grams per day

g/L	grams per liter
g/Ml	grams per milliliter
gpd	gallons per day
h	hour
ha	hectares
in	inches
in/s	inches/second
kg	kilograms
kg/L	kilogram per liter
kg/m^3	kilograms per cubic meter
km	kilometers
km^2	square kilometers
kn	knots
L	liters
lb	pounds
lb/bbl	pounds per barrel
lb/gal	pounds per gallon
L/h	liters per hour
m	meters
m^2	square meters
m^3	cubic meters
m^3/s	cubic meters/second
mg/cm^2	milligram per square centimeter
mgd	million gallons per day
mg/kg	milligram per kilogram
mg/L	milligrams per liter
mg/m^3	milligrams per cubic meter
m^3/h	cubic meters per hour
mi	miles
m/km	meters per kilometer
mL	milliliter
mm	millimeter
m/s	meters per second
nmi	nautical miles
ppm	part per million
ppt	part per thousand
v/v	volume component per total volume